TABLE OF CONTENTS

FINDINGS OF THE INDIANA NONPOINT SOURCE POLLUTION MANAGEMENT TASK FORCE
1995 - 1998

Mission Statement of the Task Force: The Indiana Nonpoint source Task Force is a group of concerned parties who have a vested interest in reducing nonpoint source pollution. The Nonpoint Source Task Force will develop strategies for reducing NPS pollution and its effects on Indiana's water resources.
It is the intent of the Nonpoint Source Task Force that this document be used in implementing nonpoint source pollution reduction programs in Indiana. It is not the intent of the Nonpoint Source Task Force that this document be used as the sole justification for government regulation.

NOTE: The Findings of the NPS Task Force are summarized below, and the complete text follows. See Chapter Three of the Nonpoint Source Management Plan for information on the history and activities of the Task Force.

NONPOINT SOURCE POLLUTION CONCERNS

Parameters present in surface or groundwater resources in amounts or at levels that indicate water quality impairments, that have been identified by the IDEM Assessment branch include:

Impaired biotic communities, cause unknown
Mercury and PCBs in fish tissue and sediment
Low dissolved oxygen or high biological and/or chemical oxygen demand
Phosphorus
Nitrates & ammonia
E. coli
Metals (copper, lead)
Oil & grease
Pesticides
Cyanide
Chlorides
Organic compounds
Sediment (not considered in assessments due to there not being a water quality standard; but it is an accepted factor in habitat degradation and also of economic concern in drinking water supplies.)

No specific causes are attributed to these pollutants, although it has generally been demonstrated that metals, VOCs, oil and grease, PCBs, and cyanide are due to industrial discharges or transport of materials produced in industrial processes. Mercury is due to industrial processes, atmospheric deposition, and improper disposal of materials from residences and businesses. Chlorides may be from waste water treatment processes. In light of the genesis of these pollutants, many are beyond the scope of nonpoint source pollution control practices, and control must take place through permitting and other regulatory measures. However, it is also widely accepted that the major sources of habitat impairment, oxygen deficits, phosphorus, nitrates, ammonia, pesticides, and sediment are partly or wholly due to nonpoint source pollutant transfer. Therefor these concerns must be addressed through a nonpoint source pollution management program, or a combination of point- and nonpoint measures.

ORIGINS AND IMPACTS OF NONPOINT SOURCE POLLUTION

The Nonpoint Source Task Force identified the following origins of nonpoint source pollution and its potential impacts on water quality:

- **Agricultural activities** introduce pesticides, phosphorus, pathogens, and sediment to water bodies via eroding land surfaces and runoff. Significant erosion and chemical movement (including pesticides, phosphorus, and pathogens) occurs primarily during the winter and late spring. During the winter months, frozen soil and snow cover result in low infiltration and increased runoff. Similarly, heavy rainfall combined with soil tillage and fertilizer and pesticide application in late spring increases the potential for polluted runoff. Nutrients and organic matter in agricultural runoff can increase oxygen demand in streams, cause eutrophication in streams and lakes, and lead to overgrowth of aquatic plants and algae. Although best management practices (BMP) are increasingly being implemented to control erosion, among other water quality problems, many streams and lakes in Indiana are still in violation of water quality standards.

- **Animal production operations and feedlots** contribute pathogens, nitrogen, phosphorus, salts, and other nutrients to water bodies from animal excrement, waste water, and spilled feed. Microorganisms and nitrates associated with animal production byproducts can contaminated water supply wells. Human health effects can include gastroenteritis or other illnesses originating from microbial pathogens. Infants are particularly susceptible to an illness called methemglobinemia caused by high nitrate levels in drinking water.

- **Streambank erosion** contributes to habitat degradation in watersheds. The morphology of unstable, eroding stream channels is complex and not fully understood. Water resources can be disrupted by habitat degradation as significantly as by runoff containing pollutants. As a result, any plan for reducing and controlling erosion and chemical movement from land must also include consideration of the hydrologic systems in the watershed.

- **Timber harvesting** can promote habitat degradation. Indiana's forests occupy approximately 20% of the Hoosier landscape and account for over 50% of the State's remaining wetlands. Forests are widely recognized for their natural contribution in minimizing nonpoint source pollution. The harvesting of timber and conversion of forest land to other uses can result in direct and measurable increases in nonpoint source pollution. This may be evidenced by increased nutrient loading, greater water volume and velocity, increased stream temperatures, and increased erosion and sediment yields.

- **Land development** is the source of increased sediment, habitat degradation, and urban runoff. Construction activities can strip sites of vegetation and expose soil, resulting in accelerated erosion and sediment loading. After construction, increased imperviousness created by additional roads, buildings, and parking lots can accelerate runoff volume and increase peak discharges. Runoff in urban areas may contain many types of pollutants, including chloride and cyanide from the application of road salts for deicing; oil and grease from automobiles; pesticides and nutrients from lawns and gardens; and excess heat from elevated water temperature caused by increased contact with heat-retaining surfaces like asphalt. Increased runoff due to development also promotes flooding, destabilizes stream banks, and alters natural water courses.

- **On-site sewage disposal units** such as septic systems can contribute nutrients and pathogens to water bodies when they malfunction. Site selection for septic systems is a major challenge in Indiana because over 70% of the State's soils are unsuitable for the operation of conventional gravity flow subsurface trench systems. Many soils are unsuitable due to slowly permeable horizons or impermeable layers, while others are unsuitable because of rapid permeability, creviced bedrock, or karst geology. Natural soil wetness (shallow depth to seasonal high water table) is also a common problem in many soils. Improper site selection for septic systems can result in the leaching of nutrients and pathogens into groundwater and surface water.

- **Solid waste disposal landfills** can be the source of polluted runoff during heavy storm events. There are hundreds of solid waste disposal landfills in Indiana. Abandoned and closed landfills can contribute to nonpoint source pollution to water bodies through runoff. Most landfills in Indiana do not have monitoring wells, and many accepted wastes that may not be accepted at landfills today.

- **Transportation-related facilities** contribute salt, sediment, metals, pathogens, pesticides, and organic compounds to water bodies. Stormwater runoff originating from transportation-related facilities are frequently discharged either directly or indirectly into Indiana's waters. In most instances, contaminants discharged are not of the magnitude to cause severe water quality problems. However, roadway runoff contains contaminants that can potentially have significant impacts on lakes, rivers, streams, and groundwater. Contaminants identified in transportation-related runoff include particulates, deicing agents, heavy metals, oil and grease, nutrients, pathogens, and pesticides, as well as sediment from construction activities.

- **Coal mining** can result in habitat degradation by increasing sediment loads and chemical pollution. Active mines alter the geology and vegetation of the surrounding area. These alterations can have deleterious affects on water flow and quality. Both surface and underground mining alter water chemistry through oxidation, dissolution, precipitation, and ion exchange reactions. Metals may be dissolved in groundwater, but if the water surfaces through a spring or mine orifice, oxidizing conditions can produce iron and manganese precipitate. This water quality degradation is generally referred to as "acid mine drainage." In 1996, 50 surface coal mines and two underground mines were active in Indiana. Due to various economic forces, however, the number of surface mines is expected to decline.

- **Oil and gas production** generates petroleum-related compounds and salt that can impair water quality. Potential pathways of contaminants resulting from the production of oil and gas include surface infiltration through the unsaturated zone; subsurface migration from underground reservoirs into fresh waster horizons through faulty wells; and runoff of spilled contaminants to surface water bodies.

- **Non-energy mineral extraction** can increase erosion and sediment loading in a watershed. Surface mined mineral resources comprise a major part of Indiana's non-energy mineral industry. Dredging, pit excavation, and quarrying are the major techniques used for surface extraction of non-energy minerals in the State. Fines, both valuable and waste, are produced from drilling, blasting and processing of mineral products. These fines must be properly handling to prevent problems associated with sedimentation and siltation.

- **Atmospheric deposition** contributes contaminants that are transported through the air and precipitation to water bodies. The atmosphere is recognized as a major pathway by which pesticides, metals, and other organic and inorganic compounds are transported and deposited in areas far removed from their sources. The deposition of contaminants may have a significant adverse effect on water quality in surface and near-surface waters and is becoming more widely acknowledged as an important contributor to the declining health of aquatic ecosystems. Bioaccumulation of pesticides and metals in biota have been documented around the world. Mercury contamination and the detection of DDT and PCBs in aquatic biota in the Great Lakes provide evidence of the long-range transport of some atmospheric contaminants.

Knowing the pollutants produced by certain land uses and activities, and knowing the pollutant concerns most often identified in water quality assessment, still leave us with important gaps in our understanding of nonpoint source pollution processes. In order to control the delivery of a pollutant to a waterbody, it is necessary to understand its origin, the ways in which it can be transported, and its fate in the ecosystem. We are still a long way from being able to link all of those considerations for any one of the pollutants which we address in our programs.

Accurate and thorough assessments of water quality condition should seek to attribute sources to identified pollutants, through monitoring program design and examination of land use and landscape characteristics, as well as human activities. It is only by knowing <u>what parameter must change in the ecosystem</u> that we may effectively address nonpoint source pollution control.

RECOMMENDATIONS OF THE TASK FORCE

Based on its findings, the Nonpoint Source Task Force made numerous recommendations to IDEM's nonpoint source management program. The recommendations fall under the following general categories: assessment, research and development, education, implementation, and enforcement of regulations.

While it is not possible for the nonpoint source management program to implement every recommendation on its own during the five-year time frame of this plan, it will 1. present the findings of the Task Force to those responsible for activities of concern; 2. promote the implementation of the Task Force's recommendations; 3. inform the public of the findings of the Task Force; and 4. use the findings of the Task Force to update the nonpoint source management plan.

The principal recommendations of the Task Force are <u>summarized</u> below. (For complete list please read the full text of the Findings). ***Project objectives*** have been developed from these recommendations to guide the nonpoint source management program in promoting nonpoint source goals through project grants. Proposals for Section 319 grant funds must address one of those objectives, listed in Section 5.3 of the NPS Management Plan.

Assessment

1. Carry out an aggressive water monitoring and assessment program that will evaluate, at a minimum, the following:

- Chemical, biological, and hydrologic effects of agricultural runoff on surface and groundwater.
- The impact of land application of wastes.
- The effect of forest land losses or gains.
- The value of riparian forests, and identify where riparian forests exist.
- The impact of land development.
- Assess closed waste disposal sites, and conduct field investigations of ground and surface water to determine the impact of these sites and identify those needing federal or state direction for cleanup.
- Determine baseline water quality in the vicinity of potential oil shale developments.

- Evaluate known impaired waters for impact from public roads, using as indicators high levels of metals in sediment, organic compounds associated with transportation, and high salt levels in groundwater.

2. Develop a spatial database for mapping watersheds, available to all watershed partners, which identifies or locates the following:
   - Waters in close proximity to public roads.
   - Solid waste disposal sites and waste containment sites.
   - Existing and abandoned, and orphaned oil and gas related fluid impoundments and oil and gas wells.
   - Critical areas where cropping, livestock production, and other agricultural activities have a high potential for impacting water resources.
   - Areas where water resources are impacted by land development.
   - Oil shale mines, surface and subsurface retorting facilities, refuse deposits, leading and transfer stations, IDNR wells of record (for ground water monitoring), background ground water sites, and effluent sampling sites.
3. Assess and document the effects on water quality of:
   - The interaction of surface and subsurface water
   - Integrated Pest Management and Integrated Crop Management
   - Widely-used Best Management Practices
   - Nutrient management planning
   - Fertilizer handling
   - Watershed planning
   - County planning and zoning regulations (and their effect on housing density).

Research and Development

1. Conduct an economic analysis of habitat removal, wetland mitigation, vegetative cover replacement, riparian vegetation loss, topsoil loss, flood damage, water treatment for human consumption, expansion of infrastructure, land use change, regulation and permitting, and the economic benefits of preventing the destruction of natural features. Incorporate this information into education and training programs.
2. Investigate the consequences of placing non-mine wastes in active or abandoned mines.
3. Evaluate the Trust Fund and Special Fund's ability to support anticipated expenses pertaining to Superfund sites; evaluate where state-lead cleanups should take place; explore ways to address sites that do not qualify under existing programs; explore ways to maintain a sufficient fiscal base for site evaluation and cleanup as a continuous effort.
4. Conduct an audit of the current oil and gas rules to determine their adequacy, effectiveness, and appropriateness.

5. Determine the chemical constituents of surface and groundwater that are elevated by mining and processing of oil shale in order to establish criteria that can be used to identify nonpoint source pollution by oil shale mining and set effluent limits.
6. Promote research to evaluate the impact road salts have on the environment and carry out a cost-benefit analysis in relation to the benefits to society. Analyze the short and long-term effects of sodium and ferrocyanide on water quality. Analyze the effects and benefits of improved salt management practices and more effective right-of-way maintenance.

Education and Information

1. Promote a credible and effective educational program for both surface and ground water protection using local, state, and federal resources to target a broad audience including county planners,

developers, engineers, agricultural producers and agribusiness, conservation agencies, foresters and loggers, local officials, public land managers, homeowners, owners of reclaimed lands, architects, lending institutions, teachers, and other stakeholders.

2. Support development of educational materials detailing the strengths and weaknesses of various BMPs (including IPM and ICM practices), including social, economic, and environmental impacts.
3. Increase operator assistance and training programs to promote and improve the skills and working knowledge of land application project managers and participating landowners.
4. Include water quality and stewardship of natural resources in educational programs that teach crop production; for example, as a requirement for Certified Crop Advisor (CCA) professional accreditation.
5. Present stakeholders with detailed cost-benefit comparisons of prevention, control, and remediation of nonpoint source pollution.
6. Improve networking and communication among stakeholders involved in information/education efforts by establishing or supporting a coordinating body to comprehensively address information/education issues in Indiana. This body could establish an exhaustive resource directory of educational materials, and identify effective curriculum for nonpoint source education in schools.
7. Facilitate the transfer of information between agencies.
8. Identify sources of government and private funding for nonpoint source programs and projects. Develop and conduct grants writing workshops to assist stakeholders in obtaining funding for nonpoint source pollution efforts.
9. Develop stringent guidelines for road salt and other chemical management, and incorporate them into training materials for road maintenance personnel. Encourage the substitution or exclusion of salt for snow and ice removal in environmentally sensitive areas. Promote the use of warm season grasses such as blue grama and buffalo grass within ten feet of the edge of pavement since they have the ability to withstand high salinity.
10. Educate agricultural producers on management of agricultural inputs with an emphasis on minimizing the movement of nutrients, pesticides, and pathogens to surface and groundwater.

Implementation

1. Provide information, technical assistance, and incentives to promote comprehensive watershed management programs by supporting local leadership.

2. Promote the use of demonstration areas where farmers, planners, industry, and the general public may view the kinds of BMPs (including IPM and ICM practices) that are effective in Indiana.
3. Foster cooperation between NRCS, SWCDs, CES, FSA (USDA - Farm Services Agency), OISC (Office of the Indiana State Chemist), agri-business and other appropriate personnel to integrate soil erosion/water quality design criteria for BMPs (including IPM and ICM practices).
4. Continue the integrated multi-agency (including private and public organizations) approach for identifying and managing resource problems and solutions in Indiana. Centralize information on resource assistance programs and technical literature.
5. Integrate fertilizer and pesticide management strategies with overall water quality goals and avoid conflicting recommendations. Promote appropriate nutrient application of cropland and lawn application, using testing and application rate technology.
6. Promote the preparation of nutrient management plans for all agricultural operations.
7. Support pesticide and fertilizer programs to assess the geographic locations and quantities applied of all crop inputs in drinking water supply watersheds or well head protection areas.
8. Implement the State Pesticide Management Plan.
9. Improve coordination between USEPA and Indiana state agencies.
10. Provide technical and financial assistance to minimize or prevent forest losses and nonpoint source impacts associated with developments in or near forest areas. Support development of regional

comprehensive land use plans and planning and zoning procedures that encourage protection and stewardship of forest land.

11. Encourage use of voluntary tools such as conservation easements and transfer of development rights.
12. Implement state, regional, and local programs that manage nonpoint source pollution using nonstructural practices which preserve, enhance, and restore buffers and natural conveyance systems; stabilize shorelines, stream banks, and channels; and protect or restore riparian forest and wetland areas, as well as those using structural practices, new surface water runoff treatment systems, and retrofits of existing systems that initially were designed only to prevent flooding.
13. Identify suitable land application sites, accessible the majority of the year. Through a joint effort of the Indiana Department of Environmental Management and the Local Health Departments, encourage local treatment plant operators to accept septage from haulers, when weather conditions prevent land application.
14. Encourage City and County Highway Departments to implement improved technologies which INDOT has successfully incorporated into their Snow and Ice Removal Procedures, such as links to the Satellite Weather Tracking System, truck-mounted pavement sensors, the computer aided system for planning efficient routes (CASPER), zero velocity spreaders, and totally contained salt management facilities.
15. Support urban runoff projects designed to reduce pollutant loadings from street runoff.
16. Integrate erosion and sediment control and other water quality programs within local stormwater management departments and utilities or within public works departments that deal with surface water resources.
17. Fully implement the Governor's Soil Resources Study Commission recommendations.
18. Fully utilize the technical, managerial, informational, and administrative expertise of SWCDs, Resource Conservation and Development Councils (RC&Ds), state and federal conservation agencies, local and regional planning commissions, stormwater departments and utilities, and other relevant organizations.
19. Establish and implement mechanisms that ensure the competency of site plans and the complete and correct execution of accepted site plans. Similarly, establish and implement mechanisms that ensure regulatory compliance throughout the duration of the construction process.
20. Develop and implement BMPs and other activities that protect, replace, restore, and promote naturally functioning wetlands, woodlands, grasslands, riparian buffers, stream banks, stream habitats, and other natural features lost to development. Similarly, use these BMPs and programs to connect preserved or restored areas that were once separate, as with corridors.
21. Develop and implement programs that prevent, reduce, and remediate sedimentation. Implement BMPs and other activities that prevent the movement of sediment during development. Research, develop, and implement the use of permeable surfaces and covers during construction to reduce runoff. To successfully achieve nonpoint source pollution reduction goals, the proportion of construction sites with controls must approach 100 percent.
22. Rank BMPs on their effectiveness using pollution prevention as the primary goal and pollution control as the secondary goal. Evaluate BMPs on their capabilities as providers of multiple functions; for example, as stabilization and sediment capture mechanisms. Include this information in guidebooks and education and training programs.
23. Revise erosion and sediment control guidebooks and model ordinances to incorporate new BMPs that minimize erosion, preserve habitat, etc.
24. Develop and implement a program to recognize developers, contractors, and other stakeholders that actively promote or use BMPs that reduce nonpoint source pollution and impacts on naturally-occurring systems during development.
25. Implement activities that reduce or prevent the effects of thermal pollution from new development. This includes, but is not limited to, creating wooded buffers between paved areas and water bodies and reforestation of stream banks and shorelines. This will require affecting long stretches of shoreline, and these activities should be coordinated and thoroughly planned for long-term

implementation.

26. Implement programs that encourage or provide incentives for owners of industrial facilities to: (a) Build enclosures or otherwise treat or prevent the release of materials that could produce nonpoint source pollution when exposed to stormwater. Where possible, substitute less harmful industrial materials or implement other industrial BMPs that can reduce nonpoint source pollution from industrial facilities. (b) Consult and utilize guidance documents such as the EPA Storm Water Pollution Prevention Plan. (c) Sample the stormwater discharges from their facilities to determine what pollutants are present and what their sources are. (d) Contact IDEM's Office of Pollution Prevention for more information about the development of pollution prevention plans.
27. Develop and conduct meetings, conferences, workshops, etc. to educate industrial facility owners on BMPs and pollution prevention. Develop accompanying training programs and guidebooks.
28. Provide industrial facilities with economic incentives to implement pollution prevention plans.
29. Promote awareness of and encourage IDOL mine inspectors and mine personnel to identify and control problematic run-off that is not directed to a sediment basin.
30. Develop MOUs between IDEM and INDOT to protect sensitive water resources in close proximity to roadways. IDEM should also encourage efforts to evaluate the effectiveness of BMPs, such as the fibrous sphagnum peat-sand filters, implemented by INDOT.
31. Explore alternative options to current bonding provisions. Include an examination of the value of instituting a Bond Pool for the purpose of distributing environmental risk and maintaining a healthy Environmental Fund.

Regulation

1. Provide adequate resources to conduct inspections and subsequent approval of confined feeding operations in a timely manner and to respond to complaints regarding water quality.
2. Implement the proposed state regulation that provides for improved regulatory oversight of waste constituents through increasing reporting requirements and recognizes land application activities and soil characteristics that pose a greater risk to water resources.
3. Local governments should fully utilize state statutes that authorize local stormwater management.
4. Inform and educate producers as to appropriate containment and spill reporting requirements for compliance in the statutes and rules under the Office of the Indiana State Chemist.
5. Develop, establish, and enforce model ordinances dealing with stormwater drainage and erosion control. Promote the use of dry wells in new development for discharging runoff or constructed wetlands effluent to groundwater.
6. Develop and utilize model ordinances that regulate the RG. Utilize 327 IAC 15-6 as a guide for developing a pollution and spill prevention plan.
7. Encourage continued oversight by OSM/IDOL so that the effects of mining operations will be continually appraised.
8. IDOL should review and approve mine plans and inspect to determine if plans are implemented and are functioning as proposed.
9. Promulgate by rule, a ranking/prioritization method for sites to be addressed for state-lead remedial action. Incorporate ground water contamination sites not subject to CERCLA such as those involving petroleum products, salts, pesticides, and fertilizers
10. Develop and implement rules for siting, construction and monitoring of surface impoundments.
11. Develop a Memorandum of Agreement between the Division of Oil and Gas the Department of Environmental Management related to the regulation of oil and gas operations.
12. Continue to actively enforce the existing oil and gas rules with special emphasis on secondary recovery operations until revised rules are implemented.
13. Promote cooperative enforcement efforts between IDEM & IDNR.
14. Monitor and regulate the quality of all surface and groundwater associated with shale loading facilities that are not part of a permit area. Obtain approval of the US Department of Interior Office of Surface Mining to regulate these facilities under Division of Reclamation authority.

15. Consider the advantages of state primacy for regulation of Class V injection wells.
16. Guidelines for handling of retort wastes should be based on the type of retort process employed. Require NPDES review of each mining/retorting operation.
17. Ensure that the fugitive dust control plans included in industrial air permits also include provisions to prevent dust suppression chemicals from entering waterways.

CHAPTER ONE: AGRICULTURAL LANDUSES

Agriculture is a large, diverse industry that plays a vital role in the economic stability of Indiana. The state has over 60,000 farms, containing nearly 16 million acres of land with about 13 million in cropland. Six million acres of corn and five million acres of soybeans are planted annually in a corn/soybean rotation. The remainder of the acreage is planted to small grains, forages, and miscellaneous crops. Indiana's livestock industry ranks in the top ten states in production of hogs, chickens, turkeys and ducks. The state processes more of the commodities produced in Indiana each year, generating added value to these commodities. There is great diversity in Indiana agriculture and the Indiana farmer has a well-deserved reputation for independent thinking and ingenuity. More than 80 percent of Indiana's farm operators live on the farm; 51 percent consider something other than farming to be their principal occupation. Utilizing state of the art technology, Indiana agriculture is feeding a growing international population while protecting our domestic natural resources.

The inter-relationship between water quality and intensive farming is complex. The livestock industry is affected by both technology and politics. Fertilizers, pesticides, conservation tillage and intensive livestock operations are key ingredients to increasing food supplies for the world while providing profits for the producers. Indiana's farmers are aware of the need to optimize production while preventing degradation of water resources and reserving marginal land for wildlife habitat, recreation and natural areas.

The aggregate of human uses which can be considered agricultural may be divided into four areas: crop cultivation (commodity crops, forage production, and turf), animal production by-products, land application of sludge and wastewater, and use of pesticides and fertilizers.

CROPLAND CULTIVATION

Issues

Twenty to 25% of Indiana's cropland is eroding at rates above tolerable levels (referred to as AT@). Although the majority of cropland is protected from soil erosion processes, water quality standards are not being attained in many streams and lakes because of **sedimentation or excessive levels of nutrients.** Conservation farming practices can reduce soil erosion, improve habitat for fish and wildlife, and generally improve water quality. The use of conservation tillage can affect both the volume of runoff water and eroded sediment, as well as the pesticide and nutrient concentrations associated with each. Crop residue cover, which is maintained in conservation tillage systems, helps to reduce soil erosion by slowing surface water runoff, increasing infiltration, and preventing surface sealing. The degree by which crop residue affects water infiltration and runoff can vary greatly between fields depending on slope, soil structure, and internal drainage.

Best Management Practices, or BMPs, are practices that have the least negative impact on the environment. Examples of BMPs include constructing facilities for the proper handling of chemicals during storage and mixing, adopting practices to reduce soil erosion, and installing vegetated filter strips to remove nutrients and pesticides from surface water runoff. There is no question that BMPs work in **controlling soil erosion and reducing runoff of pesticides and nutrients**. However, further research is needed on the effectiveness of BMPs and water quality improvement, and this research needs to be matched to local conditions. The economics of the various BMPs continues to be a key consideration among land users in deciding to adopt BMPs. Thus, general economic principles of BMPs should be studied further. Local educational projects aimed at increasing adoption rates of BMPs should be directed to assist farmers in developing farming practices which best protect water and soil quality and maintain profitability.

Finally, it is essential that all agencies (private and public) work together for the benefit of agriculture and the citizens of Indiana who use the water. Programs should be developed at the local level with the full cooperation of those who will be implementing the programs. Development of innovative, incentive-based programs will help to ensure that interest and cooperation in adopting BMPs exists at the local level.

Analysis

Agriculture is only one of several categorical generators of nonpoint source pollutants (NPS), and most agricultural NPS pollution originates in cultivated fields. Indiana agriculture is mostly rain-fed. Only the northern counties have substantial amounts of irrigation. The climatic conditions in Indiana provide two periods within the year in which significant erosion and/or chemical movement (both nutrients and pesticides) may occur. The winter months, with frozen soil and snow cover provide the potential for low infiltration and increased runoff. These events are characterized by puddled surface conditions and relatively low rates of flow for long periods of time. Generally, low sediment yields and relatively high chemical yields (due to the transport of smaller, chemically rich particles) are the result when runoff does occur.

The other period of interest is during and shortly after seedbed preparation and extends until the crop growth provides a protective canopy in late spring/early summer. During these periods, tilled soil, together with fertilizer and pesticide, can produce the potential for runoff. Since these periods correspond to the heavy rainfall season in Indiana, the combination of high surface water runoff and rainfall intensity with highly erodible land and chemically rich soil conditions is of obvious concern.

Every county in Indiana has modern soil survey information available through the 92 local Soil and Water Conservation Districts. The different soil characteristics described in the soil surveys can assist in identifying the potential for leaching and runoff. When combined with topographic and land use data, site-specific information can be collected or summarized. This kind of attention to detail allows local agencies and communities to prioritize areas with the higher potentials for soil loss and/or chemical movement. This would help allow for the further adoption of BMPs which would be most effective in that particular area.

The processes of sheet, rill and ephemeral gully erosion account for most of the sediment production from cultivated cropland. However, large scale gully erosion is a problem in some of the steeper and/or less fertile areas. Management ability of the landowner or operator often is a factor in whether or not unacceptable erosion occurs. The US Department of Agriculture-Natural Resources Conservation Service (NRCS) and Cooperative Extension Service (CES), IDNR's Division of Soil Conservation, and the SWCDs are committed to agricultural erosion control programs such as AT by 2000", which could help reduce the problem of soil erosion and NPS pollution to acceptable levels.

While efforts to reduce NPS pollution should be primarily aimed at in-field management, the problems of unstable, eroding stream channels should be addressed. Biological water quality can be disrupted just as significantly by habitat destruction as by chemical runoff. Thus, any plan for reducing and controlling erosion and chemical movement from farmland must also include consideration of the water courses that the runoff eventually uses to reach the receiving water body.

The fact that conservation tillage practices reduce soil erosion in Indiana by more than 50% illustrates why they are increasingly popular soil conservation techniques. Pesticides (herbicides in particular) are essential components of conservation tillage systems. The loss of herbicides due to regulatory actions prompted by water quality concerns has the potential to negatively impact soil conservation efforts. Adoption of BMPs to reduce herbicide runoff is critical. For example, using integrated pest management practices (IPM) such as post-emergence herbicide programs can help to reduce chemical loading into water bodies.

As described earlier (in the whole document) BMPs are actions that dealers and growers can include in their plans and activities. BMPs can be structural (e.g., a mixing load pad) or non-structural (e.g., conservation tillage). One study estimated that 22% of pesticide detects in surface water were due to carelessness in filling, mixing, and operating spray equipment next to streams. These problems are *point source* and are potentially simple to reduce or eliminate. Educational efforts continue to focus on simple improvements such as containment pads at mix/load sites and following the product label instructions.

Field BMPs include tillage and rotation practices, development and implementation of nutrient management plans, and varying the application timing of pesticides (all of which are sometimes referred to as part of an Integrated Crop Management, or ICM, system). Already available are better application techniques including GPS (global positioning systems) technology, more precise equipment calibration, a larger selection of post-emergence herbicides, and a wider variety of types of BMPs which can be used by Indiana's farmers.

Some observers have expressed concern that adoption of conservation tillage techniques requires the use of more pesticides, resulting in greater, not less, potential runoff into surface water. Numerous studies have shown no significant increase between herbicide use in no-till and conventional tillage systems. On average, herbicide runoff in no-till systems was 30% of runoff from conventional tillage systems. However, the opposite of this case can also exist. This can result when a large rainstorm event occurs after application but before soil-applied herbicides could infiltrate the soil.

Another example of a trade-off between a structural BMP and chemical runoff is the use of a WASCOB (water and sediment control basin). This terrace-like structure are used to reduce overall slope length, thereby reducing the runoff rate of water. This slowing of the water causes sedimentation to occur and the water that eventually leaves the terrace (through a channel or a subsurface drain) generally has a much lower sediment load. However, the chemical yields may not have been reduced by nearly the same amount (factors that influence chemical yields include solubility, particle size and retention time). The impoundment area could also possibly serve as a recharge area in soils with high water tables, and chemical leaching might be enhanced. Once again, research should be coordinated through the affected agencies on how to better manage chemical runoff when considering the benefits of reducing soil erosion and resulting sedimentation in WASCOB systems.

The NRCS Technical Guide and Engineering Field Manual are excellent sources of information in designing and constructing most of the structural BMPs that can be identified as applicable in Indiana. Publications from Purdue University and other Midwestern Land Grant Universities also detail cultural and structural management systems for reducing environmental impacts from agricultural production. Many pesticide product labels contain information on proper mixing, loading and application and precautions to use depending on slope, soil type, and proximity to ground or surface water. Maps indicating the spatial extent of soil associations are available and are a very good starting point for determining the vulnerable areas of the state. The Indiana Generic State Pesticide Management Plan contains vulnerability information of groundwater. Further, surface and groundwater protection strategies identify the use of location-specific and product-specific BMPs within certain areas of the state.

Several provisions of the 1995 Farm Bill (FAIRA) and current Federal Farm Legislation are having a significant effect on Indiana's agricultural sediment production. Conservation Reserve Programs are helping to retire highly erodible cropland from production, while the conservation compliance portions of the Act require actions that will reduce erosion on highly erodible fields. Gains made to date should not be lost and resources should be committed to ensure that improvements are not reversed. As agricultural erosion control practices continue to be implemented, there will be a need to evaluate the measures and determine whether they are allowing water quality goals to be attained over time. This evaluation, as well as the establishment of priorities, needs a coordinated effort among the state agencies. The primary focus should be on the site specificity of any program realizing that there is no one 'best' BMP. Instead there are a number of cultural and structural practices, that, when combined with the proper incentives, can reduce the potential for sediment and chemicals to reach the state's waters. However, additional research is needed to best determine the benefits and risks to Indiana. For example, filter strips have shown to be effective, but research is needed to optimize filter strip design, particularly appropriate widths and plant species for filter strips.

How these program recommendations are presented to the agricultural community will have a major impact on their acceptance and eventual success. The regulators and government agencies will have to speak with a unanimous voice and with the priorities in mind. Educating the agricultural community on the recommendations will be pivotal since the innovative, more progressive growers have already adopted some of these practices. Obtaining the support of the commodity groups and agricultural organizations prior to the educational phase will help ensure the success of the program.

Following are recommendations relative to needs for further reducing and controlling NPS pollution on cultivated cropland in the state of Indiana.

Recommendations

Research and Monitoring

1. Institute and fund research programs to study the interaction of surface and subsurface water quality (surface and underground drainage included) and movement as impacted by various BMPs (including IPM and ICM practices).
2. Product maps for locating critical management areas where cropping, soils, and topographic situations produce high potential for sediment and/or chemical runoff.
3. Continue efforts to evaluate chemical, hydraulic, and biological effects of agricultural runoff on streams, lakes, ponds, and other surface water bodies.
4. Continue to use and fund monitoring and evaluation techniques to assess NPS pollution in both surface and subsurface water and progress of pollution control efforts. (Note: this is also repeated in the Education and Coordination sections.)

Education

1. Develop a credible and effective educational program for both surface and ground water protection using local, state, and federal resources (e.g., River Friendly Farmer Program).
2. Support (conceptually and financially) and implement water quality oriented resource management programs such as the AT by 2000" program.
3. Support development of educational materials detailing the strengths and weaknesses of various BMPs (including IPM and ICM practices), including social, economic, and environmental impacts.
4. Promote the use of demonstration area(s) where farmers, planners, industry, and the general public may view the kinds of BMPs (including IPM and ICM practices) that are and should be used in Indiana. These may be existing sites or new ones, but should be easily accessible and distributed around the state.
5. Continue to use and fund monitoring and evaluation techniques to assess NPS pollution in both surface and subsurface water and progress of pollution control efforts.

Coordination

1. Efforts between NRCS, SWCDs, CES, FSA (USDA - Farm Services Agency), OISC (Office of the Indiana State Chemist), agri-business and other appropriate personnel should be coordinated to produce integrated soil erosion/water quality design criteria for BMPs (including IPM and ICM practices) that address both erosion and water quality problems.

2. Continue the integrated multi-agency (including private and public organizations), interdisciplinary approach for identifying and managing resource problems and solutions in Indiana.
3. Continue to encourage participation in the water quality-related provisions of federal farm legislation.
4. Continue to use and fund monitoring and evaluation techniques to assess NPS pollution in both surface and subsurface water progress of pollution control efforts.
5. Integrate fertilizer and pesticide management strategies with overall water quality goals and avoid conflicting recommendations.
6. Pursue cooperative educational/financial efforts to remediate identified problems and prevent future problematic actions.

ANIMAL PRODUCTION BYPRODUCTS

Issue

The production of livestock and poultry also results in several byproducts, most of which are useful and contribute to a more sustainable agriculture. Animal production byproducts as used here includes animal excrement (manure plus urine); waste water; spilled feed; composted mortality; runoff from open feedlots; and sometimes bedding, in certain livestock management systems. The specific components in animal production by-products that could potentially have an adverse effect on the environment, if improperly handled, are nitrogen, phosphorus, inorganic salts, organic solids, and certain microbial organisms.

The extent to which animal production byproducts from a given farm can contribute to water quality problems is very difficult to determine and measure. Many factors affect the pollution potential of animal production byproducts, such as its nutrient composition, climatic conditions, method and time of land application, state of vegetative cover, and soil classification at the application site. An improperly managed livestock production system can be a definite and significant source of nonpoint source pollution, primarily through uncontrolled runoff and/or leaching from manured cropland, livestock-grazed pasture, confined open feedlots, or nutrients leaching from feedlots and waste storage structures.

Analysis

Land application is a commonly accepted and practical method of animal production byproduct utilization. It allows recycling of animal byproduct nutrients through the soil-plant complex, providing both essential nutrients for crop production and organic matter to improve soil physical properties. However, if generally accepted management practices are not followed, application of animal production byproducts can increase the chances of potential pollutants entering waterways. Land application of animal production byproducts in Indiana must be applied to prevent runoff or impact to receiving waters in accordance with IC 13-18-10.

In addition, there are several pollution control benefits that result from applying animal production byproducts on the land. Research indicates that application on barren land can reduce runoff-induced erosion and nutrient concentrations of the runoff. On producing land, it improves the crop stand or vegetative cover, which also reduces runoff. Vegetative growth helps trap manure solids, utilizes the nutrients and reduces the amount of runoff.
The potential for nutrient loss from runoff on sloping ground B particularly nitrogen and potassium B is greater from winter applications than from spring and summer applications. If animal production byproducts must be applied when the ground is frozen, it should be done on relatively flat land to prevent runoff. Incorporation of animal by products into the soil by injection, disking or plowing, virtually eliminates the possibility of nutrients and other potential contaminants from being transported directly to surface waters.

Animal production byproducts should not be over-applied to the soil. Application rates should be established so that the amount of available nutrients applied does not exceed the recommended agronomic rate utilized by the crop being grown. Besides the threat of increased nutrient runoff into surface waters, over-application of animal byproducts to cropland may also allow soluble nutrients to be leached from the material and to contaminate ground water, or flow to surface waters through drain tiles.

Not all animal byproduct nutrients are readily available to the intended crop during the initial year of land application. The reasons are mainly due to the differences in mineralization rates of the applied material and its solubility in the soil complex. Therefore, the build-up of nutrients in the soil is a water quality and crop fertility concern. Animal byproducts are a rich source of nitrogen, necessary for proper crop development. Consequently, controlling nitrate nitrogen in the soil should be addressed with land stewardship and generally accepted management practices. Correct application rates, based on soil classifications and crop types, along with practices that control leaching and denitrification will reduce the probability of movement of nitrates in the soil. Reducing this movement addresses the concern of surface and ground water pollution.

Phosphorus from animal production byproducts has limited mobility in most soils, although soils have varying limits as to the amount of phosphorus they can absorb and retain. The clay and organic matter in soils also have the ability to hold cations and thus prevent their leaching. In the case of heavy metals such as zinc, the soil can hold large quantities in complex organic matter molecules, and when the pH is properly maintained, the solubility is reduced. Soils have a finite absorptive capacity however, and soluble cations and anions can readily move through (be leached) the soil profile when heavy rates of applied nutrients from manure exceeds soil absorption capacities.

To ensure protection of Indiana's waterways from potential pollution by livestock feeding operations, the state legislature in 1971 enacted the Confined Feeding Control Law, which requires such operation above certain sizes and those identified as having violated water pollution control laws to obtain approval for their byproduct management systems. Approval is the responsibility of the Indiana Department of Environmental Management (IDEM), which regulates land disposal of animal production byproducts. The law requires that livestock operations subject to the law provide: detention of any surface feedlot runoff water and byproducts; adequate storage capacity for feedlot runoff and byproducts along with adequate land base to permit timely disposal at agronomic rates of application.

As a result of the number of facilities subject to the law and the resources available to IDEM, concerns have been raised about the practicality of periodic inspection to assure continued compliance with the law. In addition, there are concerns about feedlots or animal confinement operations that may be causing water quality problems, but which are not large enough to be regulated by the Confined Feeding Control Law. Confined feeding operations also utilize earthen byproduct storage and treatment lagoons. Animal production byproducts help seal the bottom of lagoons that are constructed in heavy textured clay soils, thus preventing nutrient leaching. Lagoons constructed in sandy, well-drained soils, in karst terrain, in areas of high water table conditions, and require additional precautions to prevent leaching of nutrients into ground water. Tile lines must be sealed during lagoon construction in accordance with current guidelines.

Water supply wells can become contaminated by microorganisms and nitrates associated with animal production byproducts. Human health effects can include gastroenteritis or other illnesses originating from microbial pathogens. Infants are particularly susceptible to an illness called methemglobinemia caused by high nitrate levels in drinking water. In addition, the health of livestock has been shown to be adversely affected by high nitrates in their drinking water. Maintaining a separation distance, in accordance with current guidelines, between animal quarters or byproduct holding areas and properly constructed water wells is advisable. Deepening shallow wells and encasing them properly at upper levels generally can eliminate problems posed by both nitrate and microbial contamination.

Recommendations

1. Continue with programs through the Cooperative Extension Service, animal industries and government organizations that educate operators in application of generally accepted management practices to avoid surface and ground water pollution.
2. Assist the preparation of nutrient management plans.
3. Evaluate the need to codify design and operational requirements for storage structures and land application of animal production byproducts.
4. Provide adequate resources to conduct inspections and subsequent approval of confined feeding operations in a timely manner and to respond to complaints regarding water quality.
5. Institute and fund research to study innovative waste handling techniques to assess NPS Pollution control efforts.

AGRICULTURAL FERTILIZERS AND PESTICIDES

Issues

Large quantities of agricultural crop production inputs are applied to Indiana cropland each year resulting in concerns about the impact cropping practices may have on water quality. The mobility of these inputs in water is not uniform and the precise information on these features are not readily available to the general public. USGS studies indicate that some widely used pesticides have been found in low levels in Indiana's groundwater. These studies show that the quantity of the most widely used pesticides lost with eroded soil is significantly less than that dissolved in the surface water runoff. This suggests that managing crop inputs in surface water is to manage field runoff. The evolution of current pesticides has reduced the amount of active ingredient and has also resulted in the chemicals being site specific. Many surface and nonpoint source pollutants generated by agriculture are also generated by other industries and urban areas, thus it is not easy to accurately determine agriculture's contribution to nonpoint pollution. Through various regulatory measures, the storage and handling facilities of crop inputs are carefully monitored through the office of the Indiana State Chemist. This has resulted in less contamination due to inadequate storage or handling techniques. Educational efforts need to continue to focus on simple improvements such as containment pads at mix/load sites and following the product label instructions.

Analysis

The use of crop inputs is regulated under a wide variety of federal and state statutes. The Federal Insecticide, Fungicide and Rodenticide Act, the Federal Food, Drug and Cosmetic Act, the Clean Water Act, the Safe Drinking Water Act and others all regulate these products. Congress has provided for an increasingly comprehensive regulatory system for pesticides through numerous amendments to these acts and has mandated the reevaluation and re-registration of products on a periodic basis. States are moving forward in developing state pesticide management plans to address the use of specific products where groundwater may be vulnerable. The leadership of the Office of the Indiana State Chemist (OISC) has produced a good starting point with the Indiana State Management Plan for Pesticide Use.

When soil is being lost from steep slopes or from fields with little residue protection, it was often assumed in the past that high quantities of pesticides were also being lost as well. Numerous studies have shown that the quantity of most currently used pesticides lost with eroded soil is significantly less than that dissolved in the runoff water. Pesticide solubility is an indicator of the relative percent of pesticide loss in the water phase rather than absorbed by the soil. Although significant efforts to reduce erosion in Indiana have resulted in an increase in the number of fields on which conservation tillage is used, pesticide loss will not necessarily be reduced accordingly. Managing pesticide flow in surface runoff is a key in managing pesticides in surface water. Research is further needed to advance the knowledge base in this area. Herbicide companies have identified this are and are researching compounds that will have a very short life once applied.

In areas where agriculture dominates land use, best management practices (BMPs), such as grass waterways, buffer strip, cover crops, and reduced tillage should be considered to reduce the potential for nonpoint pollution. Water quality priorities must be communicated at the local level and the individual watershed approach offers possibilities for this to occur. Additional research is needed to best determine the benefits and risks to Indiana=s water supplies. Regulators and government agencies will have to voice their priorities. Educating the agricultural community will be important since progressive producers have already adopted many best management practices. Optimization of these BMPs need to be evaluated.

Recommendations

1. Include water quality and stewardship of natural resources in educational programs that teach crop production. For example, in the requirements for a Certified Crop Advisor (CCA) professional accreditation, one of the core sections of study would be Soil and Water.
2. Strengthen support for research management involving crop inputs. Farm and nutrient management planning, Best Management Practices (BMP), Integrated Crop Management (ICM), Integrated Pest Management (IPM), and watershed approach planning are all proven techniques to improve water quality.
3. Fund pesticide and fertilizer programs to assess the presence and geographic locations of all crop inputs in drinking water supplies.
4. Emphasize product labeling in all educational programs.
5. Improve coordination of a water quality strategy between USEPA and Indiana authorities.
6. Inform and educate producers as to appropriate containment and spill reporting requirements for compliance in the statutes and rules under the Office of the Indiana State Chemist.
7. Implement and fund components of the State Management Plan.
8. Promote and enhance an aggressive agricultural fertilizer management research and education program through the public and private sectors. The objective continues to be minimization of pesticides, nitrogen and phosphorus movement to surface and ground waters.
9. Promote appropriate nutrient application of cropland and lawn application, using testing and application rate technology.
10. Establish and fund an aggressive water monitoring program.
11. Promote research to identify high risk situations involving specific pesticides, field conditions, and application techniques in order to address potential specific nonpoint problems.
12. Continue to use and fund watersheds where local and innovative best management practices are being evaluated.

CHAPTER TWO: LAND APPLICATION OF SLUDGE, WASTEWATER AND OTHER BYPRODUCTS

Issue

Land application of municipal and industrial sludge, wastewater and byproducts which are not classified under federal regulations as hazardous wastes, is a common method of resource recycling and disposal which is utilized by the majority of sewage treatment plants and by some industries in the state. Such waste and wastewaters are high in organic matter and nutrient content, rendering them suitable for use as a soil conditioner and fertilizer for agricultural land when land applied at agronomic rates. Acceptable application rates are based on the soil's inherent (but yet limited) capacity to assimilate and bind up the constituents within land-applied material, while utilizing a growing crop's ability to take up nutrients and other elements which may otherwise migrate to surface or groundwater. The potential for nonpoint source pollution resulting from land application activities is based on not only the rate of application of the material, but also the site soil characteristics and condition of the soil at the time of application.

Analysis

The land application of sludge, wastewaters, and other byproducts is regulated under the authority of the Environmental Management Act and, more specifically, under 327 IAC 6. Currently, 327 IAC 6 is being revised. It will contain numerical pollutant limits and other standards adopted from the federal 40 CFR Part 503 domestic sewage sludge regulation. There are currently 445 municipal and industrial wastewater treatment plants and other generators of byproducts are known to have active land application programs permitted under 327 IAC 6.

The current and proposed revised land application regulation specifies criteria for both contaminant loading limits and for the method of waste and wastewater application which are intended to minimize the migration of land-applied waste constituents. These criteria include site use restrictions determined by the site topography, condition of the soil and the crop being grown. The proposed revised regulation addresses these criteria as follows: Site topography considerations include slope of the land and proximity to surface waters. Surface applied liquid materials is prohibited on slopes greater than 6%. All land application is prohibited on slopes exceeding 18%. Any liquid material applied to slopes exceeding 6% must be soil injected. All materials surface applied with 300' of a stream or other body of water must be soil incorporated the day of application. Soil conditions resulting in restricted site use include frozen ground saturated soil conditions and seasonal high water tables. Land application is prohibited if the seasonal high water table is within 18" of the ground surface. If there is a soil layer with a permeability rate greater than 2" per hour between the 18" and 36" depth, application is prohibited when the water level is above 36". On a case by case basis, frozen ground application is allowed if the site slope is zero to 2% and 600' from the nearest body of water. The crop being grown or to be grown on the site impacts the potential application rate based on the crop nitrogen demand. Rates providing excess nutrients allow for increased risks of nutrient migration off site or below the crop root zone.

On February 19, 1993, the USEPA adopted the 40 CFR Part 503 regulation for the disposal of domestic sewage sludge. This regulation was developed using a complex set of risk assessment models for a number of pollutants known to be present in sewage sludge. IDEM is currently in the process of adopting the bulk of the federal standards into the existing state regulation. IDEM=s proposed regulation will maintain site use restrictions that recognize the need to conduct land application activities that minimize the potential for the migration of constituents with in the materials. The proposed language will be broad enough to allow for evaluating and limiting unusual constituents on a case by case basis.
The proposed regulation will allow for both surface application and soil injection and incorporation at controlled rates as acceptable methods of sludge or wastewater disposal. The regulation recognizes the

need to prohibit activities when soil conditions and characteristics pose greater risk of migration of waste constituents into groundwater and surface waters. Very little routine inspection of land application site use activities has been conducted. The proposed regulation will establish monthly reporting requirements allowing for closer record monitoring and quicker response by staff to respond to noncomplying activities.

Recommendations

1. Implement the proposed revised state regulation which provides for improved regulatory oversight through limiting a greater range of waste constituents, increasing reporting requirements and recognizes land application activities and soil characteristics which pose a greater risk to impact surface waters and groundwater resources.
2. Provide staffing resources necessary to implement a routine program of inspection for all land application programs to determine compliance with permits and regulatory criteria.
3. Increase operator assistance and training programs to promote and improve the skills and working knowledge of land application project managers and participating landowners. Cooperate with the NRCS, Purdue Extension and SWCDs in promoting soil conservation techniques and total farm nutrient management plans.
4. Conduct assessment of the NPS impact of land application activities in priority watersheds and implement modified site use restrictions when warranted.

CHAPTER THREE: FORESTRY LANDUSES

Acre for acre, forests are the most beneficial land use in terms of water quality. Acting as living filters, forests capture rainfall, regulate stormwater and stream flow, filter nutrients and sediment and stabilize soils. When streams and watersheds are buffered by forests, nitrogen and other pollutants in runoff washing into streams are significantly reduced and sediment levels are the lowest among Indiana land uses. Forests also retain the vast majority of atmospherically deposited nitrogen.

Forests are more an <u>answer</u> to Indiana's non-point source pollution concerns than a <u>contributor</u> of NPS pollution. Conversion of forests to any other land use is of great concern and will lead to a significant increase in NPS pollution on a per acre basis. Indiana's forests occupy approximately 20% of the Hoosier landscape and account for over 50% of the state's remaining wetlands. In addition to being a source of wood products, forested lands are extremely important as watershed protection, providers of cleaner air, habitat for wildlife, and sources of inspiration and relaxation.

While forests are widely recognized for their natural contribution in minimizing NPS pollution, certain activities can result in localized modifications of NPS pollution originating from forests or adjacent lands. These include: 1) forest management activities associated with timber harvesting, 2) grazing of woodlands with livestock or over abundant wildlife, 3) forestation practices, 4) conversion of forest land to other uses.

The following analysis looks at these and other activities and offers forest based strategies to reduce NPS pollution in Indiana.

Forest Facts

One acre of forest can remove 40 tons of carbon from the air and produce 108 tons of oxygen per year. Forest land accounts for 20% of the Indiana landscape and over 50% of its remaining wetlands. Conversion of forest land to other uses offers the most significant threat to NPS pollution from today's forest acreage. Riparian forests greatly reduce nitrogen, sediment, thermal and other NPS pollutants delivered along forested stream segments. Appropriately implemented forestry BMPs can effectively minimize NPS pollution resulting from forestry activities. Conversion of open lands to forests greatly reduces NPS pollution from those lands.

How Forests Function in Reducing NPS Pollution

Forest vegetation adjacent to streams moderates stream and water temperatures.
Trees clean the air by removing carbon dioxide and other pollutants and producing oxygen.
Forests filter sediments from overland flow.
Forests capture nitrogen, carbon and other nutrients from over land flow and atmospheric deposition.
Forests can reduce cooling costs, pollutants and soil erosion in urban areas.

ISSUE: DEFORESTATION AND DEVELOPMENT OF INDIANA'S FORESTS

Development projects which affect forest land, including loss of forest land and subdividing of ownership, are depleting forest resources and lowering water quality.

Acre for acre, forests are the most beneficial land use in terms of water quality. Acting as living filters, forests capture rainfall, help regulate stormwater and stream flow, filter nutrients and sediment and stabilize soils. Forests also capture most of the atmospherically deposited nitrogen.

Conversion of forest to any other land use is an automatic and significant increase in NPS pollution on a per acre basis.

There are direct and indirect consequences to water quality and NPS pollution when forest land is developed or converted to other uses. An undisturbed forest is the best cover type to moderate temperature and precipitation and their impacts on water quality.

Conversion of forest land to other uses, whether it be for housing, industry, infrastructure, golf courses, agriculture or almost any other uses results in direct and measurable increases in NPS pollution. This may show up as increased nutrient runoff, chemical runoff, pesticide runoff, water volume and velocity increases, increased stream temperatures, increased erosion and sediment yields or others. Research has indicated forest sediment yields consistently less than 1/2 tons per acre per year and often closer to 1/10 ton per acre per year. Contrast this to accepted, but commonly exceeded, agriculture T levels often in the range of 4 tons per acre per year.

Nitrogen and pesticide yield from forested watersheds have never been cited as a concern in Indiana. On the contrary the forest watersheds filter excess nitrogen loads delivered in runoff from non forest areas. Forests also have the ability to filter many pesticides. A discussion of urban fertilizers and pesticides can be found elsewhere in this document.

As land is developed or its use modified, runoff patterns and volumes change correspondingly. This often results in increased and concentrated water runoff into natural drainage systems unable to handle these increases without significant and occasionally gross increases in erosion. Ephemeral and intermittent stream channels often take the brunt of the impact.

Dumping or out-letting concentrated water flows into forest drainage ways as part of a development project, agricultural tiling, conservation effort or other project can be devastating. While conservation efforts in the direct project area may be note worthy, further attention is needed to prevent unintended damage to the watercourse or natural drain receiving the increased runoff.

Rates of deforestation and forest land development are difficult to come by. In Indiana's urban settings the loss of forested land has dramatically increased over the last fifty years. The demand for land to build housing and businesses has had a dramatic impact on Indiana's forest resource. In rural areas the scene is somewhat more mixed, the amount of forested land has shown a trend of increase over the last forty years in many areas while declining in others. Conversion of forests for economic development, housing, infrastructure, mining and to a lesser degree agriculture are the major causes of forest loss. Bottom line: The loss of forested land, rather than its management is a major reason for increased non-point source pollution in Indiana.

A report by Indiana's Farm Bureau Inc.'s Farm Preservation task force included data from the NRCS-Natural Resources Inventory on Broad Cover/ Use acreage for the years 1982, 1987, and 1992. During that period twenty-eight of Indiana's counties showed a loss of a thousand acres of forest land or more. Current data on the extent of Indiana's forests is being compiled as part of a U.S. Forest Service inventory of Indiana's forest resources. Significant losses are expected in several areas of rapid development in Indiana. For example: U.S. Forest Service data showed a decline in Marion county's timberland acreage from 13,400 acres in 1967 to 900 acres in 1986 and with it the loss of the forests water quality benefits.

Recommendations

1. Provide education and training for county planners, developers, engineers, agriculture interests and conservation agencies on this issue.
2. Develop educational programs demonstrating value of forest land from a NPS standpoint.
3. Provide technical and financial assistance to minimize or prevent forest losses and NPS increases associated with developments in or near forest areas.
4. Encourage technological advancements to minimize NPS pollution associated with developments in or near forest areas.
5. Support development of regional comprehensive land use plans which encourage protection and stewardship of forest land.
6. Promote planning and zoning procedures and other regulations that promote forest land retention and conservation.
7. Research how and where county planning and zoning regulations impact housing density.
8. Encourage development designs and construction which retain forest land and capitalize on its potential to minimize NPS pollution.
9. Monitor and evaluate the extent, effect and causes of forest land losses or gains.
10. Develop voluntary incentives and approaches to retain forest land and its beneficial uses.
11. Encourage use of voluntary tools such as conservation easements and transfer of development rights that protect forest land.

ISSUE: CONSERVATION OF EXISTING RIPARIAN FOREST BUFFERS

The concept of riparian forest habitat is known throughout the sciences and among professionals. However, the concept of forest areas as riparian buffers and filter strips is not as widely known. Mounting research clearly documents the value of riparian forest buffers as a major force to control NPS pollution.

Riparian forest buffers can reduce runoff nitrate levels from 13 ppm to less than 2 ppm (84 % reduction) and atrazine levels from 2.5 ppm to below 1 ppm (60 % Reduction). Sediment reductions to under 1,000 pounds per acre from several tons per acre have often been documented (80%+ reductions). Other benefits include lowered stream water temperatures, increased wildlife habitat and travel corridors, valuable wood products, stabilized stream banks and aesthetically pleasing landscapes. For every mile of 60 foot wide buffer on both sides of a stream or river 14 acres of forest and wildlife habitat is created. Birds species richness can be increase from less than 10 species to more than 25 species. Lower water temperatures benefit stream organism which in turn benefit fisheries and water quality.

Indiana has over 180,000 miles of stream and river banks and associated riparian areas. A high percentage, however, have no riparian buffers or buffers inadequate to minimize NPS pollution. With extensive waterways bisecting the landscape, the potential of positively impacting NPS pollution through the natural filters of riparian forest buffers is enormous.

Existing riparian forest buffers are pressured by encroaching development projects, infrastructure development, agriculture uses, forest practices and other activities to meet societal demands. Buffers have often been reduced in width to accommodate development and agriculture activities to the point their effectiveness to ameliorate NPS pollution is diminished. Deep forest riparian buffers are some of the most productive forests in the world and subject to timber harvest pressures. Through the use of established best management practices and researched buffer designs these riparian forest buffers can continue to produce their desired products, often in an enhanced manner, and provide the desired NPS pollution reduction benefits.

Some of the barriers associated with the conservation and protection of established forest riparian buffer areas include:

1) No clear set of riparian forest buffer guidelines established in a centralized location.
2) Insufficient training and dissemination of guidelines and technical information.
3) Concept of forest riparian buffers not fully understood by landowners, lands mangers and the general public.
4) Pressures from competing uses to convert riparian forest buffers to other uses.
5) Opportunity costs of riparian areas.

Recommendations

1. Education programs targeted to landowners, resource users, county surveyors and natural resource managers.
2. Centralize information on resource assistance programs and technical literature.
3. Provide technical assistance targeted towards landowners and resource users.
4. Provide financial assistance and other incentives for forest riparian buffer practices.
5. Increase implementation of forestry BMPs in riparian areas.
6. Establish and promote riparian forest design criteria.
7. Monitor and document the health and values of riparian forests.
8. Encourage the use of tools, such as conservation easements, and classified forests and riparian areas, to conserve and protect riparian areas.

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ISSUE: FORESTATION OF RIPARIAN AREAS AND HIGHLY ERODIBLE UPLAND

Assessment

Undisturbed forests or woodlands represent the best protection of lands from soil erosion, and pollutants (Novotny and Olem 1994). Because of the frequency of submersion and the filtering capacity of riparian areas, soil erosion and NPS pollution is a frequent problem when the riparian forest are replaced by alternative land use practices, such as farming, animal husbandry, or development.

Although often over-looked, highly erodible soils on upland sites can also contribute significant amounts of sediment to our state's watersheds-especially in the absence of adequate riparian buffers. The Natural Resources Conservation Service (NRCS) estimates that farmed highly erodible soils on slopes contributes sediment to our streams and lakes at a higher rate when the forest is removed. For example, Morley soils on 6-12% which are under corn/soybean conventional tillage contribute approximately 29 tons of soil per acre per year to our watersheds. If this land were forested, it would contribute less than 1 ton per acre/year (NRCS, Steuben County).

Significant amounts of the highly erodible and riparian land currently being farmed or pastured is marginal lands of low productivity. Forest uses, including timber production, may be the most profitable and environmentally responsible use of this land. The problem is the cost of reforestation and length of time to maturity is little incentive to the landowner to convert from one land use practice to the another. The conversion to forestland also means the potential loss of farm income.

Another problem with both of these issues is the inability of state's tree nurseries (including private nurseries) to meet current or accelerated demand for seedlings.

A number of incentive and technical assistance programs exist to encourage tree planting and forestation, including:

1) Classified Forest: program of property tax reduction and technical assistance.
2) Cost share programs administered by the USDA (e.g. EQIP, WRP, ACP)
3) Cost share programs administered by the Indiana Department of Natural Resources (e.g. Stewardship Incentive Program, Indiana Stewardship, Lake Enhancement, Fish and Wildlife small game funds)
4) Cost share programs are also available from the U.S. Fish and Wildlife Service, Indiana Nature Conservancy and other private sources.

These programs are generally poorly funded and unable to meet current or accelerated demands. Additional barriers associated with establishing forest riparian buffers and reforestation of highly erodible areas include:

1) The opportunity cost incurred when taking land out of crop or forage production.
2) Concept of forest riparian buffers not fully understood by landowners, lands mangers and the general public.
3) No clear set of guidelines established in a centralized location.
4) Cost of establishing forest riparian buffers (approx. $300/acre).

Strategies:

- Increase the availability of tree seedlings grown from local seed sources.
- Identify highly erodible and impaired riparian areas and target these areas for forestation.
- Provide technical and financial assistance for forestation.
- Develop lower cost methods of forestation.
- Continue and enhance current incentive programs.
- Encourage the use of tools, such as conservation easements, to protect riparian forests.
- Increase the implementation of forestry BMPs in riparian areas.
- Centralize information on available resource assistance programs.

ISSUE: FOREST MANAGEMENT ACTIVITIES AND NON-POINT SOURCE POLLUTION IMPACTS.

Undisturbed forests or woodlands represent the best protection of land from soil erosion and waterways from pollutants (Novotny and Olem 1994). Several activities cause disturbance in forest land, among them are: 1) Timber harvesting, 2) Forest Grazing, 3) Excessive wildlife populations, 4) Prescribed burning, and 5) Nutrient runoff.

Timber Harvesting

Forestry management practices in Indiana have not been documented to cause serious NPS problems. However, localized impacts can be significant. The greatest NPS pollution potentials arises when soil is exposed and streams are crossed during timber harvest operations. Using forestry Best Management Practices (BMPs) can minimize impacts and reduce erosion to very low and acceptable levels. When practices do cause NPS pollution the duration of impact is normally less than three years- often only one growing season, during which the site rapidly revegetates. This is characteristic of central hardwood forests.

A significant source of potential pollution resulting from timber harvesting is sedimentation originating from forest roads, skid trails, log landings, and stream crossings. It is these areas which experience significant ground disturbance. However, under selective harvesting practices (the most common in Indiana) these disturbances usually impact less than 15% of a site. Further, the infrequent nature of harvesting, every 10-100+ years, make the impact of forest practices on water quality slight when compared to other sources of non-point source pollution. The act of cutting trees down, does not alone increase soil erosion.

Preliminary findings of a monitoring study to determine the application and effectiveness of Indiana's forestry BMP's shows up to 90% compliance on logging sites visited in the Monroe watershed. Highest compliance rates were found on State Forest lands and privately owned Classified Forests. Observed BMP departures were most often associated with skid trails and riparian management zones. The poorest BMP performance was were where harvesting was done in preparation for residential development and where skidding conflicts with streams occurred.

Erosion may occur on forest land as a result of management activity, but almost always at levels below the acceptable erosion levels to agricultural lands ("T" or soil loss tolerance levels). The use of voluntary Best Management Practices with timber harvesting, even under intensive management, can reduce pollution to the point of negating adverse effects on water quality. However, BMPs are not always utilized while managing forests. Proper water diversions and placement of skid trails and stream crossings are key areas to focus future efforts.

Woodland Grazing

Livestock grazing has detrimental effects on the forest. "Forest disturbance from livestock grazing increases the erosion rates and sediment yields from forest land. This accelerates pollution of streams and lakes with sediment. This increase in erosion also results in lower fertility of forest lands from loss of organic matter...Livestock grazing in forest lands is harmful to soil conservation, water quality, timber production and wildlife habitat." (Ernst, IDNR Division of Forestry, Impact of Forest land Grazing upon Erosion Rates and Sediment Yields in the Privately Owned Forest lands of Martin, Dubois, Pike and Warrick Counties 1978).

One of the greatest watershed benefits of forest land and its porous soils is ability to accept and filter large volumes of water. Livestock grazing decreases soil porosity, which in turn decreases infiltration and increases runoff (Patrick and Helvey 86). When infiltration is decreased so is the capacity of the forest land to filter pollutants. Livestock grazing of forest land, while less popular than 25 years ago, is a contributor to non-point source pollution from forest land.

The primary reasons for forest livestock grazing include: 1) shade for livestock, 2) water supplies found in the forest, and 3) forage. However, forest forage value is very low, often only 1/20 the value of open managed pasture. Strategies developed to minimize NPS impacts from forest grazing must consider alternative shade, water and forage supplies.

Wildlife Damage

The effects of deer browse or heavy wildlife populations on the water quality is poorly documented at this time. The amount of plant matter still on the ground in browsed areas is probably sufficient to curb erosion and maintain the forests' filtering effects. However, the lack of data on this subject prohibits detailed analysis of this issue. DNR biologists have noted signs of erosion in Indiana State Parks where browsing has been the heaviest, but there is no scientific data available. The problem of overpopulation, which is the reason for over browsing and the resultant NPS problem, is currently being addressed by controlled hunting and other wildlife management measures.

Prescribed Burning

The effects of prescribed burning on water quality are minimal. What prescribed burning does occur is undertaken with considerable caution and oversight. In general, prescribed burning in Indiana does not create a hot enough fire to expose bare mineral soil and therefore is not a significant water pollution issue. Indiana Forestry BMP guidelines, as well as existing burning policies and regulations, provide adequate mechanisms to minimize impacts on water quality.

Nutrient Runoff

Problems of nutrient runoff from forest lands are minor. Research on paired watersheds in the Hoosier National Forest showed temporary increases in nutrient loads after harvesting activity, but not so large as to approach or exceed drinking standards of "T" values for agriculture. Discharges returned to baseline measures within two years of activity. The harvesting that occurred on these watersheds was conducted with Best Management Practices. Riparian zones can filter out nearly all of the nutrients lost before those nutrients reach water bodies. It should also be noted that the use of fertilizers in Indiana forest management is very rare.

The strategies listed below will help minimize NPS pollution resulting from forest management and forest activities.

Strategies

1. Increase voluntary implementation of forestry BMPs for timber harvesting, prescribed fire and other forestry activities.
2. Monitor and assess the implementation and effectiveness of forestry BMPs to control NPS pollution.
3. Assess the current impact of timber harvest operations and other forestry activities on NPS pollution to aid in NPS program development.
4. Widespread education programs targeting forest owners, forest managers and forestry industries on forestry NPS issues and methods of minimizing NPS pollution.
5. Utilize demonstration areas depicting practical application of forestry BMPs and the benefits of preventing NPS pollution.
6. Provide financial and technical assistance and other incentives to landowners, land managers and forest industry for implementation of BMPs and NPS minimizing strategies.
7. Provide technical and financial assistance to minimize NPS pollution from livestock grazing of forest lands.
8. Improve alternate livestock watering technologies.
9. Increase enrollment of land in the Classified Forest program which requires a forest management plan which includes watershed protection provisions.

CHAPTER FOUR: LAND DEVELOPMENT AND MAINTENANCE

The development of land to accommodate growth can result in a variety of potential nonpoint source (NPS) pollution problems. The potential for such problems is greater where development is unmanaged, sprawling, or dense. Haphazard, unplanned residential and commercial development can impose numerous costs on communities, creating both ecological and economic consequences. For example, environmental degradation can affect an interconnected network that includes farming, fishing, potable water supply, recreation, and tourism (Arendt, 1994). The pollution of surface and groundwater by nonpoint sources also is an economic issue. Sustainable economic development and environmental protection can be facilitated in part by intra- and inter-governmental coordination, especially in subdivision and site plan reviews. There is a growing body of evidence that resource conservation is both economically and socially beneficial for many communities. For example, studies have suggested that clustered developments with preserved, open-space areas tend to increase property values (e.g., Edwards-Jones et al., 1996; Garrod and Willis, 1992).

Construction activities such as regrading can strip sites of vegetation and expose soil, resulting in accelerated erosion and sediment loading. After construction, increased imperviousness created by additional roads, buildings, and parking lots also can accelerate erosion and increase sediment loading. Runoff in urban areas may contain many types of pollutants, such as chloride and cyanide from the application of road salts for deicing, hydrocarbons from automobiles, pesticides and nutrients from lawns and gardens, and excess heat from elevated water temperature caused by increased contact with heat-retaining surfaces like asphalt. Development also promotes flooding by destabilizing streambanks and altering natural water courses. Where sewers and storm drains are connected, flooding further contributes to NPS pollution by accelerating erosion and creating combined sewer overflows (CSOs).

Apart from the substances normally recognized as pollutants, soil erosion can significantly degrade water quality. Research conducted by the Maryland Department of Natural Resources on the Chesapeake Bay (Md.) watershed suggests that forestland can produce around 50 tons of sediment per square mile annually (Ebenreck, 1988). In contrast, land stripped for development can produce approximately 25,000 to 50,000 tons per year per square mile. Eroded sediments enter Chesapeake Bay tributaries, carrying nutrients and pollutants that are causing considerable damage to the bay.

State regulatory mechanisms currently in place only control NPS pollution loadings marginally because they are limited in scope and applicability. Rule 5, for example, which requires erosion control plans for construction sites, applies only to sites of five or more acres. Similarly, few localities have taken advantage of the non-regulatory control measures available to them. Comprehensive site and community planning, whether accompanied by restrictive ordinances or not, could help resolve many problems associated with NPS pollution. Recognizing that the goal of continued growth through development may conflict with the goal of maintaining water quality integrity supports and encourages the development and use of effective best management practices (BMPs). Moreover, coordinating the cumulative effects of individual decision-making and incremental change reduces the likelihood that a series of independent actions will contribute to an undesirable outcome. Coordinated reviews of plans at the intra- and inter-governmental levels can help avoid potential NPS problems. Additionally, a watershed management approach typically requires inter-governmental coordination of individual or multiple development projects.

A more detailed discussion of the issues associated with NPS pollution that results from new and existing development is contained in the following sections. Additional discussion builds on issues by presenting an analysis of associated problems and their recommendations. The recommendations are in no way meant to be exhaustive of all possible solutions. Rather, they serve as a starting point and impetus for creative thinking about the development of innovative approaches to reducing or eliminating sources of nonpoint pollution.

ISSUE: THE EFFECTS OF EXISTING DEVELOPMENT

Stormwater runoff from existing development can create a number of water quality problems. Impervious surfaces (e.g., parking lots, roads, roofs) can degrade water quality by altering hydrology, and chemicals associated with urban areas (e.g., fertilizers, pesticides, salts) can degrade the quality of runoff. By increasing runoff rates and volumes (stormwater is less able to infiltrate soils under urbanized conditions), development can modify or destroy natural conveyance systems (e.g., streams and rivers) and buffers (e.g., wetlands and ponds), accelerating soil erosion and causing sediments and other contaminants to be deposited in waterways. Sediments and chemicals can harm riparian and aquatic habitat, clog or damage drainage structures, and reduce the quality of surface water.

While there generally is widespread acceptance of several management tools (e.g., land-use plans, structural and nonstructural best management practices, regulatory enforcement, finance mechanisms such as fees or taxes that provide behavior-modifying incentives) that address these concerns, many developed and urbanizing communities do not to utilize them; as a result, they often fail to mitigate the adverse effects of imperviousness on water quality and manageability. For example, outdated land-use plans that lack provisions for managing storm water runoff actually may worsen drainage problems when communities experiences rapid growth. Moreover, numerous communities do not adequately enforce existing statutes or local ordinances that regulate development. By not preparing for or addressing the impacts of development on water resources, communities ultimately may incur higher costs when forced to address these problems in the future.

Analysis

Information and data on the detrimental effects of unmanaged development has been collected and disseminated in recent years, thereby promoting greater awareness among decision makers and allowing developers to incorporate this knowledge into new projects. Despite recent successes, a great deal more can be done to mitigate the adverse effects of existing development on water quality and habitats.

The deposition of sediments into state waterways is perhaps the greatest concern associated with existing development and urbanization. The Indiana Department of Environmental Management has estimated that urban runoff, including sediment from uncontrolled construction sites, may contribute to the impairment of 570 miles of Indiana rivers and streams and 3,621 acres of lakes and reservoirs (IDEM, 1989). Sedimentation creates suspended particles that can increase turbidity, thereby reducing the amount of sunlight available to aquatic plants, interfering with the ability of fish to locate prey, impairing gill functioning, reducing biological populations, and generally decreasing stream productivity. Silt deposition can destroy benthic organisms, their habitats, and fish spawning areas by smothering fish eggs and larvae, further impacting fisheries. In addition, sediment can fill drainage ditches, culverts, storm sewers, streams, ponds, lakes, and reservoirs, as well as cause a need for increased treatment of water used for public and commercial purposes, leading to higher maintenance costs for treatment facilities.

Existing development also can contribute to thermal pollution of waterways. Buffer removal along streams, lakes, and wetlands, together with stormwater runoff from impervious surfaces can increase water temperatures within these waterways. Water temperature increases are detrimental to native fish and invertebrate populations and can reduce dissolved oxygen levels.

Efforts to address sedimentation and other problems often are impeded by the difficulty in identifying viable, sustainable sources of funding to pay for preventive practices (including education), improvements, and remediation. One possible funding source (the land owner) has little economic incentive to finance the implementation of best management practices (BMPs) or the reparation of damaged natural features. Costs for doing so can be high, and often are not sufficiently offset by credits, subsidies, or benefits created by the implementation of BMPs. Enforcement of violations typically is limited or absent. Moreover, owners of upstream properties may not be adversely affected by existing development where impacts are realized downstream and off-site. For the most part, businesses face similar disincentives. For example, both businesses and land owners require returns on their investments. The business or land owner may not finance a BMP if it does not pay for itself over a given time period.

Another barrier to protecting water quality can be found in urbanizing areas with infrastructures that cannot sustain current levels of development, and therefore cannot handle periods of peak flow during significant storm events. In addition, highly urbanized areas may lack physical space for implementing systems to treat and control surface water. Guidebooks have been developed on systems that can be adapted to meet the needs of densely-populated cities.

A final barrier involves the broad array of chemicals used to maintain existing development. Because numerous types of chemicals are employed, pollutant loadings can be diverse, thus creating a need for diverse solutions. It is widely acknowledged, however, that institutional advancements have reduced the adverse effects of fertilizers, pesticides, and other chemicals on water quality. A 1988 Indiana law requires the training, registration, and licensing of lawn care professionals. Still, numerous businesses and home owners apply these chemicals without professional consultation, contributing to the likelihood that such actions will have negative impacts on water quality.

Historically, local governments have worked to manage runoff and, indirectly, to achieve NPS pollution reduction goals by creating stormwater management departments or by integrating stormwater management within established public works programs. However, local governments increasingly are reducing their dependencies on taxes and general appropriations, relying on user fees and charges as mechanisms to finance NPS pollution mitigation, stormwater control, and other resource protection programs. While this transition can be difficult, these stormwater programs benefit from the more dedicated, secure funding arrangement. Moreover, some local stormwater utilities and departments have begun to address water quality issues.

Currently, most institutional mechanisms which mitigate the adverse effects of existing development are state initiatives. The Soil and Water Conservation District Act [IC 14-32] assigns the State Conservation Board the responsibility of coordinating with state and federal agencies, through Soil and Water Conservation Districts (SWCDs), the implementation of erosion and sediment control programs that affect water quality. This Act also requires the Division of Soil Conservation, under the direction of the State Soil Conservation Board, to coordinate the T-by-2000 soil conservation and water quality protection program. This program was proposed in December 1985 by the Governor's Soil Resources Study Commission to reduce soil erosion and sedimentation in Indiana. The General Assembly has provided enabling legislation and funding for portions of this voluntary program, which includes a non-agricultural erosion control component. This component now is referred to as the Urban Conservation Program within the Division of Soil Conservation, Indiana Department of Natural Resources.

Further, the USDA Natural Resources Conservation Service (NRCS) is available to provide technical assistance through SWCDs, and also through the seven Resource Conservation and Development (RC&D) Councils serving multi-county areas. RC&Ds are coalitions of private citizens, with representation of local governments, that are coordinated by NRCS.

The Environmental Management Act [IC 13-7] and Water Pollution Control Act [IC 13-1-3] prohibit the addition of any pollutant into public waters and grant authority to IDEM for enforcement.

Historically, little has been done to monitor or regulate sediment discharges because of their pervasiveness and the improper perception that sediment is not a pollutant.

Recommendations

1. Develop innovative, effective measures to prevent as well as control NPS pollution in priority watersheds. Implement state, regional, and local programs that manage NPS pollution using nonstructural practices which preserve, enhance, and restore buffers and natural conveyance systems; stabilize shorelines, stream banks, and channels; and protect or restore riparian forest and wetland areas.
2. Implement state, regional, and local programs that manage NPS pollution using structural practices, new surface water runoff treatment systems, and retrofits of existing systems that initially were designed only to prevent flooding.
3. Local governments should fully utilize state statutes that authorize local stormwater management. The Department of Stormwater Management [IC 8-1.5-5-1] and Municipal Sewage Works [IC 36-9-23-1] statutes both authorize municipalities to collect revenues to support stormwater management programs. Training programs and guidebooks should be developed and revised to enhance the utilization of existing state statutes.
4. Integrate erosion and sediment control and other water quality programs within local stormwater management departments and utilities or within public works departments that deal with surface water resources. Training programs and guidebooks should be developed and revised to facilitate these efforts.
5. Implement watershed management programs that address, among other things, water quality problems related to development. Watershed management plans can include multiple stormwater management departments, utilities, or programs and related initiatives like wetlands management and conventional public works programs (e.g., roads and highways). Training programs and guidebooks should be developed and revised to facilitate the development of watershed management plans.
6. Identify priority watersheds that exhibit water quality problems as a result of land development. Focus remediation efforts on these watersheds.
7. Identify priority sites within watersheds that exhibit water quality problems as a result of land development. Focus remediation efforts on these sites.
8. Compile and document data and information on the impacts of development on surface water quality and on the various approaches taken to control, mitigate, or remediate these impacts. This database can be used to monitor, evaluate, and refine approaches to NPS pollution management. This information should be incorporated into guidebooks and training programs.
9. Evaluate the effectiveness of widely-utilized best management practices (BMPs). Use this evaluation to refine BMPs. This information should be incorporated into guidebooks and training programs.
10. Provide discussion forums or workshops for local officials, public managers and departmental staff, developers, contractors, land and home owners, and other stakeholders to build consensus and develop multi-disciplinary approaches to managing NPS pollution.
11. Develop and implement educational and training programs for local officials, public managers and departmental staff, developers, contractors, land and home owners, and all other relevant stakeholders demonstrating their roles in managing NPS pollution. Along these lines, implement training and other programs that urge local and state agencies to enforce existing ordinances and regulations.
12. Provide land owners and developers with economic incentives for implementing programs that prevent, control, or remediate NPS pollution generated from development.
13. Develop, establish, and enforce model ordinances dealing with stormwater drainage and erosion control. Training programs and guidebooks should be developed to enhance the utilization of these model ordinances.
14. Fully implement the Governor's Soil Resources Study Commission's recommendations.

15. Fully utilize the technical, managerial, informational, and administrative expertise of SWCDs, Resource Conservation and Development Councils (RC&Ds), state and federal conservation agencies, local and regional planning commissions, stormwater departments and utilities, and other relevant organizations.
16. IDEM should monitor the effectiveness of the aforementioned recommendations.

ISSUE: THE EFFECTS OF NEW DEVELOPMENT

Development may be viewed as a threat or as an opportunity. In the past, new developments typically consisted of changing natural features to fit a preconceived plan, resulting in the need to control stormwater runoff by artificial means. Proactive comprehensive planning and coordinated subdivision and site plan reviews can help prevent and minimize the impacts of development on natural systems and the economy.
This section addresses the prevention and control of the effects of runoff caused by new development.

Analysis

Planning. Indiana needs a non-regulatory approach to promote the planning concepts and practices needed to prevent and control NPS pollution resulting from development. Some planning requirements, such as Rule 5, apply only to land-disturbing activities of five or more acres. The intent of Rule 5 is to reduce pollutants, principally sediment, resulting from stormwater discharges to waters of the state. Non-regulated or poorly planned sites with improper or insufficient controls also may adversely affect water quality. Therefore, it is critical that programs that stress proper planning and use of BMPs are implemented.

Habitat protection and the destruction of buffers and channels. Maintaining functional natural habitat is not always possible during development. While it is still possible to protect many natural systems and drainage features, retaining native habitat and utilizing topographical features can aid in, and reduce the costs of, planning and development. Protection of functional natural habitat and topography in a development project typically adds value to the subject property, thereby yielding higher sales prices and returns on developers= investments, greater marginal property tax revenues for the community, and an enhanced quality of life in the community.

Plant and animal species, wetlands, creeks, ponds, and natural topographical features can all be used constructively instead of being removed from developed areas. Developers spend money to remove natural features, only to spend more money trying to duplicate natural functions and features on-site or elsewhere. Naturally-draining land and wetlands are flattened, filled, and compacted, and sewers and retention ponds are constructed to replicate the functions they once performed. In addition, money is spent to mitigate wetland loss. Acres of trees are bulldozed, then nursery-grown trees are put in their place. Natural buffers along rivers and lakes are lost to lawns, rip rap, and other artificial erosion control structures. Humans, wildlife, habitat, and natural runoff controls can all benefit from development which occurs in a manner which protects nature.

Finally, some causes and effects of habitat destruction are immediately apparent. Trees, prairies, and bodies of water disappear. Some effects are not immediately apparent. Stream habitat, for instance, is affected not only by physical alteration, but by the effects of thermal pollution and changes in normal water temperature caused by external sources.

Pollution prevention and water quality. The prevention of pollution is the preferred choice for dealing with pollution in Indiana. It also is the most cost-effective option over time because wastes not produced do not have to be handled, controlled, treated, or disposed.

Preservation of water quality is vital to the survival of all plants and animals. It also is vital to state and local economic development. Efforts to prevent or mitigate NPS pollution have increased since the late 1970s, but many problems still exist. The greatest sources of NPS pollution from new development are erosion and sedimentation. Sedimentation from development can clog sewers, ditches, streams, and lakes. Exposed soils typically move most when exposed directly to rain, but can also migrate off-site through wind and construction vehicle traffic. Preventing and reducing soil movement to water resources is crucial. New development also may contain provisions for treating effluent. General surface and groundwater quality impacts should be considered not only in terms of new development, but also in the assessment of the effects of development on conditions in the future. High-quality surface and groundwater is particularly important in business expansion and recruitment, in residential water supply potability, and in the economic and social benefits derived from resource-based recreational opportunities.

Management practices. Developers who implement BMPs may give little attention to ranking practices based on their effectiveness in controlling and preventing NPS pollution, or to their potential multi-functionality. In addition, new and innovative BMPs may also be ignored because they have not been properly tested or engineered. The theoretical development of new techniques in the private and public sector suggests that the limits of BMPs have not been reached. Accordingly, there remains an important need to develop and implement new, innovate, and cost-effective BMPs.

Recommendations

1. Develop education and training programs that teach planning officials, developers, architects, contractors, lending institutions, schools, land owners, and other stakeholders how to (1) prevent and reduce NPS pollution during development, (2) protect habitats, buffers and other natural features during development, (3) minimize soil exposure, movement, and on-site sediment loss, (4) remediate the impacts of construction activities on water quality, and (5) implement innovative or effective BMPs that prevent, control, or reduce NPS pollution during development. Operators of development sites must know of regulatory requirements and make efforts to comply.
2. Research, develop, promote, and utilize model site plans. Include a thorough preventive approach to NPS pollution and incorporate innovate or established and effective BMPs. Actual plans provide tangible evidence of successes and failures. Guidance on how to develop site plans should also be developed and incorporated into existing guidebooks for erosion control and stormwater management.
3. Establish and implement mechanisms that ensure the competency of site plans and the complete and correct execution of accepted site plans. Similarly, establish and implement mechanisms that ensure regulatory compliance throughout the duration of the construction process.
4. Conduct and present to stakeholders detailed cost-benefit comparisons between prevention, control, and remediation of NPS pollution. The results of the analyses should be incorporated into aforementioned training and education programs. Development, like any business, is driven by profits. Proven figures reinforce recommendations.
5. Develop and implement BMPs and other activities that protect, replace, restore, and promote naturally functioning wetlands, woodlands grasslands, riparian buffers, stream banks, stream habitats, and other natural features lost to development. Similarly, use these BMPs and programs to connect preserved or restored areas that were once separate, as with corridors.
6. Develop and implement programs that prevent, reduce, and remediate sedimentation. Implement BMPs and other activities that prevent the movement of sediment during development. Research, develop, and implement the use of permeable surfaces and covers during construction to reduce runoff. To successfully achieve NPS pollution reduction goals, the proportion of construction sites with controls must approach 100 percent.
7. Rank BMPs on their effectiveness using pollution prevention as the primary goal and pollution control as the secondary goal. Evaluate BMPs on their capabilities as providers of multiple functions;

for example, as stabilization and sediment capture mechanisms. Include this information in guidebooks and education and training programs

8. Revise erosion and sediment control guidebooks and model ordinances to incorporate new BMPs that minimize erosion, preserve habitat, etc.

9. Conduct research to determine the costs of removing and duplicating habitat and other natural features. Activities of this type include wetlands mitigation, vegetative cover replacement, riparian area loss, topsoil lost to erosion, damage from flooding, water treatment, expansion or improvement of infrastructures, land-altering activities, regulation and permitting, and more. Similarly, conduct research to determine the economic benefits of preventing or reducing the destruction of natural features. This information should then be incorporated into education and training programs.

10. Develop and implement a program to recognize developers, contractors, and other stakeholders that actively promote or use BMPs that reduce NPS pollution and impacts on naturally-occurring systems during development.

11. Implement activities that reduce or prevent the effects of thermal pollution from new development. This includes, but is not limited to, creating wooded buffers between paved areas and water bodies and reforestation of stream banks and shorelines. This will require affecting long stretches of shoreline, and these activities should be coordinated and thoroughly planned for long-term implementation.

12. Develop and utilize model ordinances that regulate the use of dry wells in new development for discharging runoff or constructed wetlands effluent to groundwater.

13. IDEM should monitor the effectiveness of the aforementioned recommendations.

The aforementioned recommendations are not exhaustive, but a starting point and framework for developing innovative projects that prevent, reduce, and control NPS pollution in Indiana.

ISSUE: THE EFFECTS OF NONPOINT INDUSTRIAL POLLUTION

In considering NPS pollution from new and existing development, one major concern that often is overlooked involves stormwater runoff from industrial facilities. Industries engage in a number of activities that expose pollutants to stormwater, creating the potential for significant NPS pollution problems. When mixed with industrial pollutants, stormwater runoff may contain any combination of pollutants produced in activities such as material loading and unloading, equipment cleaning, recycling, airport deicing, vehicle parking, fueling, and maintenance, painting, raw material handling, and intermediate, final, and waste product handling.

Analysis

Since the 1992 adoption of 327 IAC 15-6 (Storm Water Discharges Associated with Industrial Activity), several EPA-targeted industries have been required to develop pollution prevention plans for the point source discharges of stormwater. (A list of these targeted industries can be found in 40 CFR 122.26(b)(14) or in 327 IAC 15-6-4.) However, these facilities typically comply with this rule only when discharging stormwater from a point source, thereby excluding facilities that produce NPS pollution and are not targeted by existing stormwater control regulations.

Recommendations

1. Implement training programs and guidebooks that promote awareness of the link between NPS pollution and industrial facilities and develop plans to prevent industrial NPS pollution.

2. Utilize 327 IAC 15-6 as a guide for developing a pollution and spill prevention plan. Develop training programs and guidebooks that can further assist the USEPA in developing pollution and spill prevention plans.

3. Implement programs that encourage or provide incentives for owners of industrial facilities to: (a) Build enclosures or otherwise treat or prevent the release of materials that could produce NPS

pollution when exposed to stormwater. Where possible, substitute less harmful industrial materials or implement other industrial BMPs that can reduce NPS pollution from industrial facilities. (b) Consult and utilize guidance documents such as the EPA Storm Water Pollution Prevention Plan. (c) Sample the stormwater discharges from their facilities to determine what pollutants are present and what their sources are. (d) Contact IDEM's Office of Pollution Prevention for more information about the development of pollution prevention plans.
4. Develop and conduct meetings, conferences, workshops, etc. to educate industrial facility owners on BMPs and pollution prevention. Develop accompanying training programs and guidebooks.
5. Provide industrial facilities with economic incentives to implement pollution prevention plans.
6. IDEM should monitor the effectiveness of the aforementioned recommendations.

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WASTE STORAGE AND MANAGEMENT

ISSUE: ON-SITE SEWAGE DISPOSAL

For many years, pollution from septic tank effluent has been recognized as a contributor to the pollution of surface and groundwater in Indiana. On-site wastewater disposal can be divided into two broad areas: designing and siting new systems, and the repair or replacement of existing systems which may be affecting water quality.

A major problem regarding site selection for on-site systems is the fact that over 70 percent of the state's soils are unsuitable for the operation of conventional gravity flow subsurface trench systems. Many of the soils are unsuitable due to slowly permeable or impermeable layers; still others are unsuitable because of rapid permeability, creviced bedrock, or karst geology. Natural soil wetness (shallow depth to seasonal high water table) is also a common problem in many of the soils.

There are, by best estimates using U.S. Census data, in excess of 800,000 on-site sewage disposal systems in Indiana; permits are being issued annually for more than 15,000 new on-site sewage disposal systems. Approximately 32 percent of Indiana residences utilize an on-site sewage disposal system for sewage disposal; this trend is expected to continue.

Problems that have been documented include subdivisions where individual water supply wells have been contaminated by septic tank effluent; and the discharge of septic tank effluent into streams, sinkholes, and even into abandoned mine shafts. The impact of these improper sewage disposal practices on surface and ground water can be significant.

Analysis

The Indiana State Department of Health (ISDH) has been involved in on-site sewage disposal since its creation. Although the agency's emphasis for residential on-site systems has always been to train, guide, and assist local health department personnel and individuals to ensure that these facilities are properly sited, installed and maintained, ISDH promulgated its first statewide residential on-site rule in 1978. The current rule, 410 IAC 6-8.1, is administered by local boards of health. This rule applies the scientific methods of site evaluation and system design and installation developed by Purdue University during its On-Site Waste Disposal Project from 1980 to 1985. The State Department of Health has provided on-site system design guidance to commercial projects beyond the reach of sanitary sewers for the last 60 years. In 1987, the agency promulgated Rule 410 IAC 6-10, which requires a construction permit from ISDH for septic tank-absorption field systems for a commercial on-site sewage disposal system. This program, operated by ISDH, also incorporates the scientific methods of site evaluation and system design and installation developed by Purdue University during its On-Site Waste Disposal Project from 1980 to 1985.

ISDH is also cooperating with the Indiana Department of Environmental Management, the Indiana Department of Natural Resources, the Indiana Geological Survey, and Purdue University to further its goals of prevention of public health hazards and water pollution from failing on-site sewage disposal systems. This cooperation includes assistance to local health department, communities, and individuals for the elimination of discharges from failing on-site sewage disposal systems.

ISDH is currently involved in planning to further enhance the prevention of public health hazards and water pollution from failing on-site sewage disposal systems. This planning includes:

1. Reorganization of the residential and commercial on-site programs to increase efficiency and reduce duplication.

2. Revisions to the residential and commercial rules.
3. Increased educational programs for local health departments, developers, and septic system installers.
4. Work with Purdue University for:
    a) Development of a data collection program whereby ISDH can work with local health departments for better data collection on the location and performance of existing on-site sewage disposal systems, and
    b) the operation of an experimental on-site sewage disposal program whereby Purdue can inventory research on existing experimental systems and then provide testing of new technologies for use in Indiana.

Recommendations

There are programs in place in Indiana for the regulation of the installation of on-site sewage disposal systems, the application of new technologies to further reduce associated hazards; and the elimination of such systems when they exhibit failure.
However, existing programs should be enhanced by further research and education.

ISSUE: SEPTAGE DISPOSAL

Septage is that material pumped from septic tanks used for sanitary wastes. Currently, there are approximately 325 licensed septic tank cleaners operating wastewater management businesses in Indiana. These operations provide a valuable service to residents who rely on septic systems (on-site wastewater disposal systems) for sewage disposal. Based on treatment limitations built into publicly-owned sewage treatment plants, available land application sites is a future need. Increased development, outside the boundaries of publicly owned sewage treatment systems, will further increase the need to identify available land application sites. Improper land application of septage, carries with it the potential for contamination of ground water and surface water by bacteria, viruses, nitrates, and other pollutants. Proper land application siting, accompanied by close monitoring of sites and disposal options, will be necessary.

Analysis

At the request of the Indiana State Board of Health, the Indiana General Assembly in 1982, amended the Environmental Management Act (IC 13-7), to provide for the comprehensive regulation of septic tank cleaners. The Wastewater Management Rule (327 IAC 7) promulgated under that authority, became effective July 21, 1985, and regulates the cleaning of sewage disposal systems and the transportation, storage, treatment, and final disposal of the collected wastewater.

With respect to land application of septage, the rule requires that all sites be approved prior to use, based on compliance with suitability standards. Technical information regarding soil permeability, depth to ground water, and slope must be provided to the Indiana Department of Environmental Management in a report prepared by a certified soil scientist. All information is then verified through an on-site soil scientist. One hundred ten sites for land application of septage are approved by the Indiana Department of Environmental Management. The majority of these sites are located in regions where sewage treatment plants do not have the capacity to handle septage, or treatment plants have a management policy which discourages accepting septage.

As of 1996, full responsibility of the septage disposal rules have been transferred over to the Indiana Department of Environmental Management, including the licensing of haulers, record keeping of disposed materials and approval of land application sites (along with site inspection).

Land application of septage is limited by the field conditions impacted by various weather conditions. Wet weather and cold temperatures limit the accessibility to land for application of septage. Additionally, weather conditions can increase the potential for runoff to bordering waterways, if application is improperly timed or not incorporated into the soil. Haulers are required to indicate alternative disposal methods should weather conditions prevent land application.

Recommendations

1. Identify suitable land application sites, accessible the majority of the year;
2. Through a joint effort of the Indiana Department of Environmental Management and the Local Health Departments, encourage local treatment plant operators to accept septage from haulers, when weather conditions prevent land application;
3. Educate the citizenry on land application of septage.

ISSUE: CLOSED LANDFILLS/ABANDONED WASTE DISPOSAL SITES

Throughout Indiana there are hundreds of solid waste disposal landfills, some of them once open dumps, that were used prior to 1969 when permitting of landfills began. Since 1969, there have been over 100 permitted solid waste disposal landfills closed. Both abandoned and closed sites can contribute to NPS pollution through runoff, including sediments, and ground water contamination. Most of these landfills do not have monitoring wells. Some of these facilities accepted hazardous wastes or special wastes which would be treated differently today. Therefore, closed landfills and abandoned waste disposal sites, including sink holes, present a potentially significant but unquantified threat to water quality.

Abandoned waste disposal sites have caused or are suspected of contributing to surface and ground water contamination in many locations within the state. This contamination impacts public health, public water supplies, private wells, and the environment. There are many sites not identified as of yet which could pose future threats to waters of Indiana.

There are both federal and state programs to deal with some of these problems. The Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) and its 1986 re-authorization and amendments (SARA), more commonly known as Superfund, represent federal legislation designed to provide for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment. They also provide for the cleanup of inactive or abandoned hazardous waste disposal sites. Superfund provides authority and funding for the government to conduct necessary corrective actions in the absence of responsible parties to perform the work.

State programs include Leaking Underground Storage Tanks, Brown fields, State Cleanup, Emergency Response, and Voluntary Remediation. Indiana was one of the first states to address, through statutes, the liability issues associated with buying, selling or developing property contaminated by hazardous substances through IDEM's Voluntary Remediation Program (VRP). The VRP was established in 1993, pursuant to Indiana Code 13-7-8.9, in response to a growing need for the IDEM's review and oversight of voluntary investigations and response actions, primarily involving property transactions.

The VRP provides a mechanism for site owners, operators or potential purchasers who voluntarily enter an agreement with IDEM to cleanup contaminated property. When the cleanup is successfully completed, IDEM will issue a Certificate of Completion and the Governor's office will issue a Covenant Not to Sue to the cleaned property. The voluntary nature of the VRP benefits owners, real estate purchasers, lending institutions and developers. At the same time, the VRP benefits the environment and the public interest by the resulting identification and cleanup of contaminated property.

As of the end of 1996: Indiana has 6,473 Leaking Underground Storage Tank sites with 1,139 of these sites needing no further action or having been discontinued; the number of Superfund sites has been reduced from 36 to 33; the State Cleanup Program has 20 active sites and 5 inactive sites; the IDEM's Emergency Response Section has 27,072 sites on record of which there are 3,532 active spill sites and 4,037 sites in remediation; there are also 130 sites enrolled in IDEM's Voluntary Remediation Program.

Sites addressed under the Superfund program can be expected to be dealt with in a comprehensive manner over the long term with adequate attention to potential and actual water contamination. The primary deficiencies in the program are the inability of the state to adequately address sites that do not qualify for Superfund or other program's attention, and the amount of time it takes to complete a Superfund project.

Analysis

Under the authority of the Environmental Management Act, IDEM can regulate some closed landfills through 329 IAC 3.1 and 329 IAC 10, although some past owners have escaped any post-closure responsibility through bankruptcy proceedings.

Some of the closed landfills have been reviewed for action under the federal Superfund law. Unless significant public health or environmental threats give these sites high enough priority for federal actions, most closed landfills that are causing water pollution must be investigated and their problems corrected using state staff and resources.

The Solid Waste Rule has and will continue to remedy some of these complications of liability and monitoring for closed sites and sites that will undergo closure. The rule requires thirty years of post-closure maintenance and monitoring along with financial assurances that the maintenance and monitoring will occur.

Sites become eligible for Superfund either as an emergency situation or based upon the federal Hazard Ranking System, a site scoring model. Placement on the National Priorities List (NPL) occurs only if the site score is sufficiently high. Potential Superfund sites are evaluated, scored, and nominated for the NPL by IDEM staff through a federal grant-funded program. Sites may also be added to the NPL via nomination by USEPA. Most other sites on the list under evaluation will not be eligible for Superfund, yet will require some governmental lead for remedial action to reduce or prevent water contamination.

Cleanup of sites which may not qualify for the Superfund program become the responsibility of the state, without federal assistance. These sites may be addressed through several mechanisms, such as state enforcement utilizing the Hazardous Substances Emergency Trust Fund. As of January 1997, there are 16 state enforcement sites and 2 state funded cleanup sites. Although some degree of success is accomplished through each of these approaches, each option has limitations and deficiencies.

State enforcement actions are allowed by the Indiana Environmental Management Act (IC 13-30), as amended by Senate enrolled Act No. 459 of the 1987 Legislature, which contains provisions regarding identification and liability of responsible parties.

A second statutory deficiency has involved the utilization of the Hazardous Substances Emergency Response Trust Fund. The Trust Fund was established by the legislature to finance both the state's contribution for Superfund cleanup and hazardous substances removal and remedial actions at state-lead sites. States and federal law both allow for cost-recovery from responsible parties. Recent legislation allows any money cost-recovered to be returned to the Trust Fund and not to the general fund. The ability to cost-recover into the Trust Fund provided for a much stronger fiscal base that will allow the state to address more abandoned hazardous waste sites.

The cleanup of abandoned waste disposal sites is a time consuming and resource-intensive activity. The number of sites known to need attention surpassed the availability of staff and Trust Fund money to deal with them all expediently. Since the number of sites that can be addressed is directly related to the availability of resources, a prioritization system is to be established by rule, so that sites posing the greatest risk to the public are addressed first.

Recommendations

1. The deficiencies of the state to adequately address sites that do not qualify under existing programs needs to be addressed. Also an evaluation of the Trust Fund and Special Fund to support anticipated expenses pertaining to Superfund and state-lead cleanups should be done. The exploration of ways to maintain a sufficient fiscal base for sites evaluation and cleanup needs to be a continuous effort.
2. Promulgate by rule, a ranking/prioritization method to order the sites to be addressed for state-lead remedial action. Incorporate ground water contamination sites not subject to CERCLA such as those involving petroleum products, salts, pesticides, and fertilizers.
3. Prepare or revise the preliminary assessment rating for all of the closed waste disposal sites. Conduct field investigations that include private well, as well as sediment impacts on water quality, sampling at these sites in priority order, and identify those needing federal or state direction for cleanup.
4. Develop a spatial database for mapping by watersheds, which contains specific layers for recognition, information and education about containment sources for other watershed partners.

SOLID WASTE LANDFILLS

Indiana Solid Waste Regulation 329 IAC 10, which became effective in April 1996, adequately addresses NPS issues for solid waste landfills. The regulation requires that the future landfills will have synthetic liners besides the clay barriers to reduce the possibility of contaminant discharge into the subsurface. Liner leak detection plans will be submitted along with the leachate collection system with disposal or recycling options. Plans must be submitted for diversion of surface water run-on and runoff control systems and erosion and sediment control measures.

Daily and intermediate cover is required to avoid any pollution or odors discharging to the atmosphere. The final cover includes synthetic liner, clay barrier and vegetative cover. Municipal solid waste landfills are required as part of the permit requirement to establish a Corrective Action Contingency Fund (CACF) to prepare the facility to meet any groundwater corrective action that may arise during the active life and post-closure care of the site.

Recommendation

1. With programs in place in Indiana for the regulation of solid waste landfills, the monitoring of active and closed sites and corrective action requirements in place, it is not necessary to address the issue further through the NPS Management Plan.

CHAPTER FIVE: TRANSPORTATION

Stormwater runoff originating from transportation-related facilities are frequently discharged either directly or indirectly into Indiana's waters. In most instances contaminants discharged are not of the magnitude to cause severe water quality problems. However, roadway runoff contains contaminants which can potentially have significant impacts on the lakes, rivers, streams, and groundwater. Contaminants identified in runoff waters and of concern include particulate material, deicing agents, heavy metals, hydrocarbons, nutrients, pathogenic bacteria and pesticides.

The transportation-related issues identified as contributors to Nonpoint Source Water Pollution are as follows:

Road Deicing Materials
Public Roads
Railroads
Airports
Boating
Construction

This section will focus on these issues, the analysis of their contribution to NPS Water Pollution, and the recommendations and best management practices to reduce the NPS Water Pollution. Regardless of whether under state, county, or city jurisdiction, or private interests, these recommendations and suggested practices shall be prescribed to protect Indiana's waters from NPS pollution to the greatest extent practical.

Common considerations affected by the issues listed above are:

Precipitation Runoff
Ground Water Quality
Soil Erosion
Surface Water Quality
Contaminated Sediments
Spills of Contaminants
Wetlands

Also included as considerations to aid in developing a strategy or management program to reduce NPS Water Pollution are:

Monitoring (Data Collection)
Planning and Management
Education (Outreach)

There exist indirect effects to water quality other than visible pollution, such as the change in water temperature, decrease of oxygen levels, or the loss of in-stream habitat. These effects are caused by one or more of the transportation-related issues in combination with some of the common considerations (e.g., construction causing soil erosion or precipitation runoff washing contaminants from public roads or boat wakes perturbing contaminated sediments, etc.)

In order to resolve the NPS water pollution problems which are identified in the State it will be necessary to eliminate the pollutants or causes at their origins. As envisioned by Congress, the particular process by which this is to be achieved is through application of *Best Management Practices* (BMP's). BMP's can be roughly defined as categorically specific measures that have been determined to be the most effective and practicable means of reducing water pollution to a level compliant with water quality standards. BMP's typically are applied as a system of practices, rather than singly, and are chosen on the basis of site-specific conditions that reflect social and economic influences as well as technical feasibility.

The Indiana Department of Transportation (INDOT) is responsible for 11,414 miles of highways, including 2,897 miles of interstate. The county and city governments are responsible for another 81,019 miles of roads and streets. Indiana has a total of 673 airport facilities, 556 private and 117 public-use. The 556 private facilities are broken-down in the following types:

417 Airports
126 Heliports (mainly Hospitals and some TV & Radio Stations
2 Seaplane Bases
11 Ultra-Light Parks

The 117 public-use facilities are made-up of the following types:

109 Airports (90 Paved & 27 Turf)
2 Heliports
4 Seaplane Bases
2 Ultra-Light Parks

Indiana has approximately 4,407 miles of mainline railroad track. There were 240,810 watercraft registered in Indiana in 1996.

This section was written using a number of reference documents and research reports. A list of the referenced literature can be found at the end of this section. Reference to the various documents and reports are called-out throughout this section.

ISSUE: ROAD DEICING MATERIALS

Large quantities of salt are applied to roads, streets, highways, and parking lots each winter to thaw and prevent ice formation that would create hazardous driving conditions. The use of road deicing compounds, primarily sodium chloride (rock salt), has reached a seasonal average (1991-1995) application level in Indiana of approximately 465,000 tons (Tables 1, 2, & 3). Deicing compounds also include calcium chloride as a pre-wetting agent to enhance the performance of sodium chloride; however, the quantity of this and other anti-clumping agents are relatively negligible. INDOT and Indiana's city and county highway departments typically mix their salt with sand at least at a 50%-50% ratio. However, to minimize the sand sediments from clogging the inlets in urban areas the larger cities typically will use straight salt. The amount of deicing compound use will vary with the severity of the winter and the number of winter storms. Also with Indiana's geographical location the amount of salt use widely varies from the North part of the State to the South. Eight counties use no salt at all, they use crushed aggregate, cinders, or even saw-dust to improve traction. These counties rely mainly on the sun to melt the ice and snow.

TABLE 1. INDIANA DEPARTMENT OF TRANSPORTATION
SALT USE OVER THE PAST FIVE YEARS

WINTER SEASON	***SALT USE in TONS***
1991-1992	268335
1992-1993	329,220
1993-1994	355,877
1994-1995	215,915
1995-1996	403,325
5 Year Average	314,534

1995-1996 APPROXIMATE USE BY DISTRICT (Heavy Snow Season)

INDOT DISTRICTS	***SALT USE in TONS***
Crawfordsville	63,000
Fort Wayne	68,000
Greenfield	75,000
LaPorte	83,000
Seymour	46,000
Vincennes	35,000
Toll Road	30,825

5 YEAR AVERAGE BY DISTRICT

INDOT DISTRICTS	***SALT USE in TONS***
Crawfordsville	41,245
Fort Wayne	57,374
Greenfield	54,391
LaPorte	82,703
Seymour	25,746
Vincennes	21,087
Toll Road	31,988

TABLE 2. COUNTY SALT USE OVER THE PAST FIVE YEARS IN TONS.

#	*COUNTY*	1991	1992	1993	1994	1995	*AVE.*
1	Adams	229.40	77.26	99.56	142.43	147.47	139.22
2	Allen	1,476.90	3,233.07	4,347.42	3,354.80	5,330.39	3,548.52
3	Bartholomew	438.00	202.00	522.00	691.00	525.00	481.60
4	Benton	50.00	50.00	50.00	50.00	50.00	50.00
5	Blackford	53.78	63.43	73.09	68.35	71.04	65.94
6	Boone	1,725.52	1,010.52	1,038.92	2,000.28	978.06	1,350.66
7	Brown	225.02	161.33	143.30	313.39	650.23	298.65
8	Carroll					886.60	886.60
9	Cass	485.90	135.97	448.96	1,106.20	335.62	502.53
10	Clark	400.00	350.00	400.00	350.00	400.00	380.00
11	Clay	39.13	47.45	78.00	94.55	172.32	86.29
12	Clinton	80.00	0.00	80.00	80.00	160.00	80.00
13	Crawford	0.00	0.00	0.00	0.00	0.00	0.00
14	Daviess	64.53			50.03	140.17	84.91
15	Dearborn	880.43	824.56	289.80	635.95	842.68	694.68
16	Decatur	114.00	109.75	197.79	66.89	163.00	130.29
17	Dekalb	509.97	455.92	1,004.88	798.62	931.29	740.14
18	Delaware			689.54	600.46	902.46	730.82
19	Dubois	42.85	43.88	130.84	166.43	172.46	111.29
20	Elkhart	1,413.54	1,603.00	2,411.94	1,862.06	1,985.95	1,855.30
21	Fayette	271.41	156.08	386.70	422.49	746.04	396.54
22	Floyd	776.73	0.00	719.10	1,559.49	596.12	730.29
23	Fountain	172.00	152.00	175.00	117.00	465.00	216.20
24	Franklin	578.00	506.00	551.60	949.72	853.29	687.72
25	Fulton	368.47	117.39	170.39	507.99	251.10	283.07

26	Gibson	45.30	40.42	66.58	92.17	52.31	59.36
27	Grant	300.00	170.54	278.18	390.84	423.94	312.70
28	Greene	247.05	99.53	48.73	121.44	245.55	152.46
29	Hamilton	1,910.73	926.16	1,175.52	1,516.53	841.09	1,274.01
30	Hancock	645.96	228.25	416.87	1,170.07	2,182.18	928.67
31	Harrison	84.94	350.44	33.32	92.72	198.30	211.94
32	Hendricks	818.00	483.00	449.00	726.00	1,158.00	726.80
33	Henry	315.06	291.50	206.45	601.97	137.72	310.54
34	Howard	550.00	550.00	659.75	523.50	630.00	582.65
35	Huntington	500.00	500.00	500.00	500.00	500.00	500.00
36	Jackson	31.97	0.00	0.00	0.00	65.33	19.46
37	Jasper	670.10	443.11	643.35	787.95	749.86	658.87
38	Jay	114.50	170.90	45.90	177.60	49.90	111.76
39	Jefferson	0.00	0.00	0.00	0.00	0.00	0.00
40	Jennings				200.00	400.00	300.00
41	Johnson	556.17	696.85	899.79	1,373.68	1,264.03	958.10
42	Knox	131.55	21.05	0.00	151.38	198.72	100.54
43	Kosciusko	750.00	700.00	800.00	740.00	924.00	782.80
44	Lagrange	554.24	1,078.35	1,050.34	756.26	1,520.19	991.88
45	Lake	4,683.27	4,010.22	6,456.13	6,507.34	7,278.19	5,787.03
46	LaPorte	1,577.04	2,501.81	4,777.45	5,467.70	2,014.67	3,267.73
47	Lawrence	300.00	300.00	300.00	300.00	572.00	354.40
48	Madison	1,093.14	315.03	438.96	656.32	193.10	528.51
49	Marion	SEE	TABLE 3	INDPLS.			
50	Marshall	762.00	473.00	892.00	1,266.00	925.00	863.60
51	Martin	0.00	0.00	0.00	0.00	0.00	0.00
52	Miami		242.36	356.20	159.09	240.42	249.52
53	Monroe	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00

54	Montgomery	179.17	276.42	417.50	645.42	466.75	397.05
55	Morgan	590.00	600.00	803.00	798.00	1,175.00	793.20
56	Newton	375.00	202.72	273.83	249.08	652.29	350.58
57	Noble	419.00	351.00	415.00	442.00	1,765.00	678.40
58	Ohio	192.12	137.17	133.33	99.90	188.35	150.17
59	Orange	0.00	0.00	0.00	0.00	0.00	0.00
60	Owen	70.09	117.49	109.97	219.68	275.29	158.50
61	Parke		408.79	624.63	540.73	926.68	625.21
62	Perry	40.00	10.00	30.00	110.00	30.00	44.00
63	Pike	0.00	0.00	0.00	0.00	0.00	0.00
64	Porter	805.00	2,234.00	1,988.00	1,655.00	1,210.00	1,578.40
65	Posey	0.00	40.06	36.09	101.82	79.34	51.46
66	Pulaski		300.00	190.00	360.00	250.00	275.00
67	Putnam	561.26	272.19	393.96	520.22	699.39	489.40
68	Randolph	89.28	70.45	93.11	227.24	244.40	144.90
69	Ripley	150.00	150.00	150.00	150.00	150.00	150.00
70	Rush	0.00	0.00	0.00	0.00	0.00	0.00
71	St. Joseph		2,634.00	4,493.00	3,099.00	1,549.00	2,944.00
72	Scott	0.00	0.00	0.00	0.00	0.00	0.00
73	Shelby	181.00	175.00	235.00	193.00	218.00	200.40
74	Spencer			20.85	27.00	59.62	35.82
75	Starke	2,369.20	2,335.65	1,182.43	869.96	752.98	1,502.04
76	Steuben	358.64	482.21	1,245.11	25.37	1,131.16	648.50
77	Sullivan	65.13	68.87	46.20	48.84	168.19	79.45
78	Switzerland	0.00	0.00	0.00	0.00	0.00	0.00
79	Tippecanoe	917.12	685.21	570.63	491.59	869.59	706.83
80	Tipton	0.00	0.00	0.00	0.00	0.00	0.00

81	Union	478.00	525.00	335.00	495.00	635.00	493.60
82	Vanderburgh	753.00	307.00	727.00	2,198.00	471.00	891.00
83	Vermillion	292.84	182.69	183.56	294.80	270.26	244.83
84	Vigo	212.38	188.87	345.65	375.71	651.36	354.79
85	Wabash	640.11	163.34	553.46	428.66	354.04	427.92
86	Warren	80.00	100.00	160.00	270.00	175.00	157.00
87	Warrick	0.00	0.00	61.43	456.62	613.02	226.21
88	Washington	0.00	0.00	0.00	0.00	0.00	0.00
89	Wayne	1,556.86	1,378.45	1,883.05	1,301.30	2,618.24	1,747.58
90	Wells	247.49	124.26	222.47	196.16	343.86	226.85
91	White	332.65	835.24	1,236.50	1,364.99	1,004.01	954.68
92	Whitley	411.60	168.09	297.37	239.16	114.17	246.08
TOTALS		40,903.54	40,916.30	55,459.48	60,260.94	62,130.78	54,038.44

TABLE 3. Eighteen of Indiana's Larger Cities' Salt Use Over the Past Five Years in Tons.

CITY	**1991**	**1992**	**1993**	**1994**	**1995**	***AVE.***
Anderson	2,167.63	2,167.63	2,601.16	2,601.16	3,757.23	2,658.96
Bloomington	1,274.41	600.00	589.55	700.00	700.00	772.80
Columbus	1,957.00	1,678.00	1,622.00	2,058.00	2,090.00	1,881.00
East Chicago	1,200.00	1,300.00	1,400.00	1,200.00	1,175.00	1,255.00
Elkhart	3,000.00	3,000.00	3,000.00	3,000.00	2,000.00	2,800.00
Evansville			1,827.50	1,500.00	1,620.00	1,649.17
Fort Wayne	6,150.00	4,861.00	6,310.00	8,112.00	6,118.00	6,310.20
Indianapolis	25,192.00	28,274.00	29,190.00	29,688.00	39,899.00	30,448.60
Kokomo		1,975.00	2,495.00	1,991.00	4,212.00	2,668.25
Lafayette	2,048.15	1,536.72	1,897.92	2,689.15	2,186.76	2,071.74
LaPorte	437.65	611.92	674.07	499.00	712.96	587.12
Michigan City	1,237.81		1,113.16	6,285.48	1,562.66	2,549.78
Mishawaka	2,100.00	1,200.00	2,500.00	2,100.00	2,600.00	2,100.00
Muncie				2,310.44	1,718.39	2,014.42
Richmond	1,973.00	1,710.00	1,938.00	2,410.00	3,259.50	2,258.00
Terre Haute	1,047.64	432.65	684.08	1,330.61	1,653.41	1,029.68
Valparaiso	1,031.00	983.00	1,479.00	1,242.00	1,703.00	1,287.60
Vincennes	145.20	56.49	24.27	44.98	44.21	63.03
TOTALS	50,961.49	50,386.41	59,345.71	69,761.82	77,012.12	64,405.35

Salt compounds used in roadway deicing may reach surface waters in three basic ways:
1) as dissolved salts in roadway runoff,
2) percolation through the soil to the water table,
3) directly when ice and snow containing salts are dumped into watercourses.

Salts reach the ground water mainly from stock-piles, leaking storage facilities, and from uncontrolled mixing, loading, and cleaning areas. During percolation through the soil the sodium cations (Na+) become associated with clay particles present while the anions (Cl-) either percolate to the water table or are discharged to surface waters.

Analysis

Potential environmental impacts of roadway salts include: damage and loss of roadside vegetation (16, 17), increased salt concentrations in soils, lakes, rivers and streams near highways (10, 11, 20, 26), increased salt concentrations in groundwater supplies (4, 8, 10), introduction of ferrocyanide into soils, groundwater, lakes, rivers and streams, and increased salt loadings to private waste water treatment plants or public owned treatment works (POTW=s). Recent studies (15, 18, 22) indicate that a substantial portion of the total chloride loading to Lake Michigan is directly attributable to winter use of road salts.

Although numerous studies have demonstrated salt concentrations to increase dramatically in surface waters adjacent to roadways (8, 9, 10, 20), a significant impact on aquatic life has not been readily documented. In general, salt loadings are temporary and normal dilution may be great enough to reduce the immediate problem. However, surface waters which lack an outlet or have long flushing times may experience continually increasing salt concentrations which may influence aquatic organisms. Important wetland vegetation may be lost from high concentrations of sodium chlorides and calcium chlorides.

A chemical of concern contained in road salt is cyanide. This chemical is added routinely at the supplier level to prevent clumping together in high humidity situations. Even if the purchaser does not request the anti-caking agent, it is necessary for the supplier to introduce it to facilitate manageability at the barge, railroad, and delivery operations. These anti-caking chemicals cannot be removed after delivery. The two agents added are:

- **Ferric ferrocyanide** (Prussian Blue) Ferric ferrocyanide is generally added to road salt at 40-50 ppm.
- **Sodium ferrocyanide** (Yellow Prussiate of Soda) Sodium ferrocyanide is generally added at 40-50 ppm.

The Food and Drug Administration has approved Yellow Prussiate of Soda for use in food products up to levels of 13 ppm. This cyanide is considered bound, because it resists degradation into its primary forms under normal salt handling conditions. Because of strong chemical bondage between the cyanide groups and the iron, ferrocyanides have a low order of toxicity. There has been documented cases of several grams of sodium ferrocyanide being ingested repeated without apparent ill effects. The scenario where the bound cyanide would be broken down so that free cyanide could be released would be prolonged exposure to sunlight. However, do not mix with hot or concentrated acids and do not expose solutions to sunlight for any length of time to avoid generation of hydrogen cyanide. Waste ferrocyanide in streams and lakes should not exceed 2 ppm because irradiated solutions become toxic to fish. Since the cyanide is added at relatively low concentrations to road salts, 40-50 ppm, and it is diluted by rain/melting snow, the measured cyanide levels at all 18 of the INDOT sites investigated by Backburn Architects, Inc. was found to be insignificant. A study has shown that this stable molecule degrades in sunlight, but either seeps into the ground or flows downstream before anything more than negligible happens. (6) Free cyanide is less stable, and very toxic, and the free cyanide bonds with water rapidly to form a harmful chemical.

In a Minnesota study, Biesboer and Jacobson (1994) studied the role of road salt in limiting germination in six warm season grasses and surveyed roadside soil salt concentrations during a one-year period. Salt levels were measured at prescribed intervals from roadsides. Soil chloride concentrations were highest in the winter (October-May), reaching 22,000 parts per million (ppm) and fell below 2,500 ppm in the summer and early fall after spring rains flushed away accumulated salts. Areas within six feet of busy roads were either largely devoid of vegetation or the originally planted grasses were replaced by undesirable, weedy non-grass species. This pattern was attributed to several factors, including salt accumulation in roadside soils due to winter salting operations. They found that salt concentrations were highest within the first three feet from the edge of pavement and then rapidly declined within thirty feet. They concluded that most warm and cool season grasses could germinate and grow beyond ten feet from a road without experiencing salt stress. Planting grasses within ten feet of a road requires careful selection for salt tolerance. In particular, warm season grasses such as blue grama (Bouteloua gracilis) and buffalo grass (Buchloe dactyloides) are attractive choices due to their ability to withstand high salinities. The study found that the number of germinating seeds was inversely proportional to snowmelt salt concentration and only two undesirable species, purple loosestrife (Lythrum salicaria) and common cattail (Typha latifolia), germinated when exposed to undiluted snowmelt. This finding may explain why these two species often become dominant in urban wetlands in northern states such as in Indiana. Overall, it was found that species diversity, evenness, and richness in the study greenhouse plots decreased significantly with increased snowmelt concentration. Total biomass also declined. This information underscores the importance of substituting or excluding road salt from environmentally sensitive areas.

There are numerous documented cases of ground water and well contamination by salt stockpiles and salt applications. In recognition of the problems, State and municipal transportation agencies have attempted to assess and improve storage and application procedures to eliminate the problems. INDOT has implemented or is studying new technologies to improve their deicing practices. These technologies include:

1) Links to Satellite Weather Tracking System
2) Truck-Mounted Pavement Sensors
3) Electronic Spreader Control System
4) Pre-wetting Process
5) Computer Aided System for Planning Efficient Routes (CASPER)
6) Zero Velocity Spreaders
7) Contracted a Consultant to Study and Make Recommendations for Improving Layout and Handling Procedures for Salt Storage, Mixing, Loading, and Clean-up at Existing Facilities.
8) Design and Construction of New Totally-Contained Salt Storage, Mixing, Loading, and Clean-up Facilities.

INDOT is using a new **weather tracking system** that will save approximately $34,000 in its first year of implementation and approximately $25,000 each year for the next two to five years. The **Data Transmission Network (DTN)** is a state-of-the-art system that provides accurate, real-time weather information without the burden of modems, long-distance calls or use of personal computers. This user-friendly system provides color data which can be viewed in regional or a detailed, local perspective. The system can also generate information such as temperature and wind speed. Each INDOT sub-district and district office will have the system so they can better plan their snow and ice removal work; thus, saving time, money, and reducing deicing materials needed.

INDOT is installing 24 additional **truck-mounted pavement sensors** on its fleet, bringing the total number of pavement sensors to 44 in Indiana. Using infrared light, the sensors can detect pavement temperatures which help managers and drivers determine when and how to treat a road with salt, sand, or calcium chloride, and whether treatments are even needed. INDOT tested the use of the devices in 1994 and discovered that they pay for themselves in one season through savings in materials (salt & sand), personnel(hours), and equipment. They cost approximately $2,300 each.

INDOT is using a mini-computer system known as the **Electronic Spreader Control System** to collect and store information about how much material is applied to the road per mile as well as monitor the time frame in which it is applied. INDOT can use this data when ordering materials or researching the effects of the materials. Also, as the speed of the truck increases or decreases, the hydraulic system controlling the spreading of the material increases or decreases proportionately, conserving materials. Approximately 300 INDOT trucks will be equipped to use the system this season (1996/1997). INDOT first piloted use of the device three years ago. Because this is a built-in system, the cost of this system is included in the cost of the truck.

INDOT is adding two 50-gallon tanks to its existing snow trucks. The tanks contain liquid calcium which is added to the salt as it is applied to the roadway. The liquid calcium causes the material to stick to the roadway surface and start working immediately. This **Pre-wetting** process increases the effectiveness of the material because salt requires liquid to melt ice. It will also help conserve material by making it less likely for the salt to scatter off the road. Each district is starting conversion this year with at least several trucks. INDOT has piloted these units for several years with success. Each unit costs approximately $2,500 and will save money by conserving materials (salt & sand) while it also enhances safety by placing chemicals under the snow storm (between the pavement and the ice/snow) to help prevent build-up on the pavement surface. Also, tests are being conducted to use the pre-existing equipment to dampen the road before salt is applied so that snow and ice cannot form on the roadway. INDOT will test this **de-icing process** in several locations around the State in order to gauge its effectiveness. This will also expedite the dissolution and dilution process to minimize NPS Water Pollution.

The overall goals of snow and ice removal operations are to provide a safe driving surface for the public, efficient use of maintenance vehicles and personnel, and effective use of deicing materials. INDOT=s resources needed for these operations include nearly 1,500 trained personnel and some 1,200 maintenance vehicles. The cost is over $14 million each year. Design of snow removal routes is a major determining factor of overall quality of service. Minimizing deadhead travel (travel over the network with no service being performed) is an important objective in the overall snow and ice removal operation. Each road segment in the INDOT network is routinely rated based on average daily traffic (ADT). Snow and ice removal service requirements, measured by frequency of service and by the type of service, are based on these ratings. During snow events, Class I roads (ADT>5,000) receive continuous service generally every two hours and Class II (ADT between 1,000 and 5,000) every three hours. Resources are allocated to the route network based on the historic importance of individual road segments. Efficient snow removal routes can be planned by maximizing Class homogeneity and service quality, while minimizing deadhead travel distance and the number of trucks and personnel needed. A new framework to design efficient routes is **CASPER (Computer Aided System for Planning Efficient Routes)**. CASPER integrates an extensive spatial network database (GIS/CAD), a models-based program consisting of multi-objective search heuristics and network algorithms, and a template-driven and highly interactive user interface. INDOT has used CASPER to design routes for snow and ice removal vehicles with significant cost savings. A significant improvement in the overall quality of service has been observed. CASPER optimally designs these service routes for maximum efficiency. So far INDOT has reduced the number of snow routes in the Fort Wayne District by eight using CASPER, resulting in about $400,000 in initial savings. From three Districts (Ft. Wayne, LaPorte, and Crawfordsville) 17 trucks have been taken out of the fleet. It is expected that about 50 routes statewide will be eliminated and the cost savings will be approximately $140,000 for each eliminated route over a 10 year period. As of December 1992, cost savings already realized for the State have been estimated at more than $9 million and new snow routes have been designed for approximately 40% of Indiana's rural areas.

INDOT is also testing **zero velocity spreaders**. The concept of zero velocity spreader is : project the material out of the rear of the truck at a forward velocity precisely at the speed the truck is traveling forward. The resulting velocity of the deicing material is zero relative to the roadway. This allows the materials to stay where it is effective, in the traffic lanes. Simply put, the mechanism adjusts the flow of material so that materials are set down, rather than tossed down, which conserves material. A conventional spinner spreader will cast up to 40% of the deicing material into areas outside the traffic lanes where it will do nothing to help clear the roadway. The zero velocity system has an ability to spread at speeds up to 45 miles per hour (mph), thus reducing the speed differential between the maintenance vehicle and the traffic and creating a potentially less dangerous situation. INDOT will test this program this winter (1996/1997) as a potential conservation method.

A survey of all 92 Indiana Counties and 18 of the larger cities and towns indicates a large quantity of salt being used for snow and ice control (see Tables 1 & 2). Approximately 65% of the city and county facilities cover their stored salt; however, mixing, loading, and clean-up procedures need improvements. The Environmental Protection Agency (EPA) is beginning to require cities and counties to cover their stored salt. INDOT contracted with Blackburn Architects, Inc. to evaluate 18 representative salt storage facilities and make recommendations for mitigating brine runoff from these facilities. INDOT may be able to apply the general recommendations from this study to all of their salt facilities. The final report will be submitted in 1997.

INDOT has designed a totally-contained salt storage, handling, and loading structure to be constructed at the existing salt facilities. These structures are totally enclosed buildings which will contain the salt and eliminate any contaminated runoff from the sites. Their considerable cost will require that they be phased-in when old structures have deteriorated to the point of needing to be replaced.

Regulation of salt storage and usage, in terms of water pollution control, has been a nebulous proposition, although the Environmental Management Act (IC 13-7), the Stream Pollution Control Law (IC 13-10), the State Water Quality Standards (327 IAC 2-1), and the Spill Regulation (327 IAC 2-6) all have general applicability. In recent years cities and counties have realized the environmental and economical significance of improved handling and application of salt for snow and ice removal.

Recommendations

1. Promote research to evaluate the magnitude and impact road salts have on the environment and society. Analyze the short-term and long-term effects sodium and ferrocyanide has on the environment. Conduct cost-benefit analysis on the recommended improved salt handling and management practices.

2. City and County Highway Departments need to implement improved technologies which INDOT has successfully incorporated into their Snow and Ice Removal Procedures:

A) Links to Satellite Weather Tracking System

B) Truck-Mounted Pavement Sensors

C) Electronic Spreader Control System

D) Pre-wetting Process

E) Computer Aided System for Planning Efficient Routes (CASPER)

F) Zero Velocity Spreaders

G) Design and Construction of New Totally-Contained Salt Storage, Mixing, Loading, and Clean-up Facilities.

H) Enforce strict handling procedures based on written manuals and training courses.

3. Develop stringent guidelines for handling of the salt at the storage facilities to eliminate or significantly reduce brine runoff from leaving the site. These guidelines will be in the form of manuals and training of personnel to assure that all people involved are informed of the importance of reducing NPS Water Pollution.

4. Design, Construct, and Implement improvements of the storage and handling facilities and operations to eliminate or significantly reduce brine runoff from leaving the site. Some of these improvements could include:

A) Minimize the size of the operations pad on which the salt is mixed with aggregate and loaded into the trucks.

B) Completely contain all runoff from the operations pad.

C) Store all equipment relative to the snow and ice removal on the pad in the off-season.

D) Wash the equipment at a non-salt handling facility, such as at a commercial truck wash.

E) Use a *common-sense* approach to handling the salt;

1) Do not over-fill the trucks.

2) Load the slush and snow melt from the pad onto the trucks as pre-wetting solution.

3) Carefully mix and load salt so as not to create a messy condition of the pad.

4) The salt is intended to be applied to the roads and highways and not to the storage facility or surrounding area.

5) Minimize the amount of water used to wash equipment.

5. Work with Office of Pollution Prevention & Technical Assistance (OPPTA) of IDEM, INDOT, American Public Works Association (APWA) to develop an educational outreach program for road designers and maintenance workers. The Northwest Regional Office (NWRO) of IDEM sponsored a workshop on salting practices in 1995 which could be carried out to other areas of the state.

6. Encourage the substitution or exclusion of salt for snow and ice removal in environmentally sensitive areas. Promote the use of warm season grasses such as blue grama and buffalo grass within ten feet of the edge of pavement since they have the ability to withstand high salinities.

Best Management Practices

- Cover salt storage, handling, and loading areas.
- Conduct ground water quality monitoring in areas of high de-icing salt use.
- Grade and drain storage sites to provide surface drainage away from the storage area and contain all on-site drainage. (avoid surface water ponding)
- Require judicious adherence to guidelines regarding salt mixing, loading, and application on roads.

Issue: Public roads

In general, contaminants from roadway runoff are not of the magnitude necessary to cause serious water quality problems. However, the potential to cause water quality from roadway runoff exists. In general, the environmental impact of transportation-related runoff will depend upon the type and amount of pollutants delivered to and the characteristics of the receiving water body.

Public Roads contribute to NPS Water Pollution through two basic mechanisms: *washoff* by rainfall or snowmelt and *blowoff* by wind and/or vehicular turbulence (10). Storm water running over roads may accumulate dirt and dust deposited on the paved surfaces from the air, metals and organic compounds from tires, brakes, and vehicle wear, as well as bacteria from litter and debris. Roads may also serve as conduits, receiving contaminated runoff from other sources such as parking lots, rooftops, and accidental spills. Chemicals used to maintain highway right-of-ways may also find their way into surface and ground water. In many instances, the runoff from roadways may not be significant enough to cause water quality problems. However, the potential to cause a water quality problem should be an important consideration during the planning, construction, and maintenance of our roadway system. Polluted storm water from public roads may enter the State's waters directly via storm drains, ditches, or combined sewer systems, or indirectly through infiltration into the ground water along right-of-ways. While some states are beginning to require transportation agencies to obtain Storm water discharge permits either independently or in conjunction with municipalities, Indiana currently does not regulate street and highway Storm water discharges.

The purpose of this section is to identify contaminants that may be present on typical road surfaces and may potentially cause water quality problems. Much of the information presented is from studies performed in other states or on the nation as a whole. Although not specific to pollutants contained in transportation runoff for Indiana, this information provides an indication as to the types of problems that may exist in the State.

Few studies have documented the environmental problems associated with storm water runoff from transportation-related activities. However, results from studies conducted under the Nationwide Urban Runoff Program (NURP) and similar studies that have dealt with urban storm water runoff provide a framework for examining potential surface water problems associated with transportation-related runoff (1, 26, 35).

Throughout the State a variety of materials are applied to unpaved roads to reduce fugitive dust emissions. These include petroleum products, salt solutions, and wood by-products. With the exception of a ban on using waste motor oil for this purpose, there are currently no state regulations on the use of these chemicals. Some of these materials have the potential to impact water quality under certain circumstances.

Analysis

The Federal Highway Administration (FHWA) has produced a reference manual entitled *Evaluation and Management of Highway Runoff Water Quality*, published in 1996, which summarizes the current information available on the problem of highway runoff. FHWA divides highways into urban and rural for purposes of considering NPS Water Pollution. Pollution loads from urban roads is significantly higher than that from rural highways due to the concentration of traffic, streets, and impervious surfaces. Urban areas are also more likely to suffer from heavier rates of atmospheric deposition. Table 4 compares mean concentrations of numerous pollutants in rural and urban highways from the FHWA report.

TABLE 4. Mean Pollutant Concentrations (mg/L) in Runoff from Urban and Rural Highways (Driscoll, et al. 1990).

Pollutant	*Urban (ADT*>30,000)*	*Rural (ADT*<30,000)*
Total Suspended Solids (TSS)	142	41
Volatile Suspended Solids (VSS)	39	12
Total Organic Carbon (TOC)	25	8
Chemical Oxygen Demand (COD)	114	49
Nitrate + Nitrite (NO_3/ NO_2)	0.76	0.57
Total Kjeldahl Nitrogen (TKN)	1.83	0.87
Phosphorus (as PO_4)	0.40	0.16
Total Copper (Cu)	0.054	0.022
Total Lead (Pb)	0.40	0.080
Total Zinc (Zn)	0.329	0.080

** ADT is Average Daily Traffic*

A listing of surface water pollutants associated with roadway use and their primary sources is providedin Table 5. The contaminants present at any given location will depend on factors such as traffic volume, traffic speed, climatic conditions, surrounding land use, exhaust emission regulations, highway maintenance policies, and occurrence of accidental spills (10, 26, 28). As indicated in Table 5, motor vehicles and roads contribute a broad spectrum of materials in several ways: leakage of fuels and lubricants; wear of vehicular parts; exhaust emissions; and rusting of metal parts. Atmospheric deposition and pavement and bridge wear are other common sources of roadway surface contaminants (26). The rate at which rainfall removes contaminants from street surfaces is dependent on rainfall intensity and street surface characteristics. Intense storms remove more street pollutants than light storm events. Nearly one-half of the plant nutrients (phosphorus, nitrogen), one-fourth to one-half of the heavy metals and over one-third of the pesticides found on street surfaces are associated with the finer size classes of particulate materials.

TABLE 5. Common Highway Runoff Contaminants and their Primary Sources (10, 16).

Contaminant Type	***Examples***	***Primary Source***
Particulates	Dust, Dirt, Gravel, Fine Residue	Pavement and Vehicles Wear Atmosphere Highway Maintenance
Nutrients	Nitrogen, Phosphorus	Roadside Fertilizers Atmosphere
Heavy Metals	Lead	Auto exhaust (lead gasoline) Tire Wear (filler) Lubricating Oil & Grease Bearing Wear
	Zinc	Tire Wear (filler); Motor Oil (stabilizing additive); Grease
	Iron	Vehicle Rust; Highway Structures; Moving Engine Parts
	Copper	Metal Plating; Bearings & Bushing Wear; Brake Lining Wear; Herbicides
	Cadmium	Tire Wear (filler); Fungicide Applications
	Chromium	Metal Plating; Break Lining Wear
	Nickel	Diesel Fuel & Gasoline Exhaust; Metal Plating; Lubricating Oil; Bushing Wear; Asphalt Paving; Brake Lining Wear
	Mercury	Atmospheric Deposition
Inorganic Salts	Sodium & Calcium	Deicing Salts; Grease
	Chlorides	Deicing Salts
	Sulfates	Deicing Salts; Fuel; Roadway Subbases
Petroleum Products	Oil, Grease, & Gasoline	Spills; Leaks; Antifreeze; Asphalt Surface Leachate
Pesticides (Herbicides)	Methoxychlor;	Spraying Highway

	Methyl Parathion	Right-of-way
Contaminant Type	***Examples***	***Primary Source***
Pathogenic Bacteria	Coliform Bacteria (indicator)	Soil; Litter; Bird Droppings; Truck Hauling Livestock or Livestock Waste
PCB=s	Polychlorinated Biphenyls	Atmospheric Deposition; Catalyst in Synthetic Tires
Other Compounds	Asbestos	Clutch and Brake Lining Wear
	Rubber	Tire Wear

Maintenance practices on paved roads and right-of-ways can have either positive or negative impacts on water quality. Studies show that street sweeping and catchbasin cleaning can cause significant short-term reductions in NPS Water Pollution from roads by removing the larger particle sizes. Other practices, such as bridge cleaning, repair, & painting, as well as right-of-way mowing, pesticide applications, and ditch clearing may have negative impacts. In rural areas, right-of-way maintenance may be a more significant environmental problem than the actual road surface. Many of the maintenance practices which could cause negative impacts on waters are subject to a variety of permitting requirements, including;

IDEM Article 15. NPDES General Permit Rule Program
- RULE 5 Storm Water Runoff Associated with Construction Activity
IDEM Section 401 Water Quality Certification
IDNR Lake Preservation Act
IDNR Ditch Reconstruction Permit
IDNR Navigable Waterway Permit
IDNR Construction in a Floodway Permit
U.S. Army Corps of Engineers Section 404 Permit

Concentration and loading data for selected roadway contaminants present in Storm water runoff are summarized in Table 6. The values are means for runoff samples taken during 159 storm events within four representative U.S. cities. Roadway runoff volume and associated contaminant concentrations are strongly influenced by rainfall intensity, area and configuration of drainage system, traffic volume, climatic conditions and percent of paved versus unpaved areas within the drainage area (11). Loadings for most parameters were highest for all-paved sites and attributed to the higher contaminant wash-off efficiency of accumulated material from impervious surfaces. Solids, heavy metals and chloride loadings were found to increase during winter periods for those sites using salt & sand deicing materials. Mean BOD_5 (5-day biochemical oxygen demand) values, during the initial roadway runoff period which impacts the amount of oxygen dissolved in the water, are comparable to estimates for a well operated secondary municipal wastewater treatment plant (11). Maximum values (Table 6) for many of the pollutants indicate that extreme loadings are possible.

TABLE 6. Average Contaminant Concentrations and Loadings in Roadway Runoff for Four U.S. Citi

Contaminant Sampled	*Concentration Average[3]*	*Range[2] (mg/l)*	*Loading Average[3]*	*Range[2] (lb/acre)*
TS	1147	145-21,640	51.80	0.040-535.000
SS	261	4-1,656	14.00	0.008-96.000
BOD_5	24	2-133	0.18	0-4.100
TOC	41	5-290	2.10	0.002-11.500
COD	147	5-1,058	6.90	0.004-34.300
TKN	2.99	0.10-14	0.15	0-1.040
$NO_2 + NO_3$	1.14	0.01-8.40	0.69	0-0.420
TPO_4	0.79	0.05-3.55	0.05	0-3.600
Cl	386	5-13,300	13.00	0.008-329.000
Pb	0.96	0.02-13.10	0.060	0-0.480
Zn	0.41	0.01-3.40	0.020	0-0.120
Fe	10.30	0.10-45.00	0.500	0-3.500
Cu	0.10	0.01-0.88	0.010	0-0.029
Cd	0.04	0.01-0.40	0.002	0-0.140
Cr	0.04	0.01-0.14	0.003	0-0.290
Hg x 10^{-3}	3.22	0.13-67.00	0.001	0-0.002
Ni	9.92	0.10-49.00	0.270	0.007-1.330
TVS	242	26-1,522	9.34	0.01-44.00
VS	77	1-837	3.700	0.004-28.200

To obtain kg/ha multiply lb/acre by 1.12.
[1]Taken from Gupta et al. (1981) for Denver, Harrisburg, Milwaukee, Nashville.
[2]One site was an elevated bridge (paved only), one site was an all grassy right-of-way (unpaved), and averages for other four sites included both paved and unpaved areas.
[3]Average of 151 storm events. However, not all parameters were monitored for every event.

In describing the pattern of pollutant discharge during a runoff event, the term *first flush* is commonly used for the initial portion of the runoff which typically contains the highest pollutant loadings (10, 11, 28, 33). Nationwide research indicates that the majority of pollutants are discharged into receiving waters during the initial stages of a storm and decrease with time. Peak loading rates last for a relatively short time period, but may under certain conditions reach extreme levels. However, the first flush discharge pattern varies with each drainage system and each rainfall event. The first flush pattern is less noticeable during storms having low, even rates of runoff and also when rainfall events occur close together which prevents accumulation of contaminants on street surfaces.

Based on the bulk of research on the subject, it seems reasonable to conclude that impaired waters in urbanized watersheds of Indiana are being impacted by polluted runoff from public roads. In rural areas, impacts may only occur at localized sites such as causeways and bridges where roads cross or run adjacent to sensitive waters, wetlands, and aquifers. Because there are such a large number of site specific factors influencing contributions of roads to NPS Water Pollution, it is impossible to accurately estimate their overall statewide impact. Assessment of the effects of public roads on waters should be considered on a site specific basis, taking into account the factors discussed herein
There are several ways in which storm water or snowmelt runoff from transportation-related activities may impact receiving surface waters. As previously discussed, storm water runoff from roadways often results in high-level short-term increases of particulates, toxic materials, nutrients and oxygen demanding substances. As particulates present in roadway runoff are delivered to surface waters and settle out, the associated contaminants may exert long-term impacts on surface water quality and the aquatic organisms. Results from urban runoff studies indicate that urban runoff particulates act as a constant source of small amounts of slowly dissolving toxic materials, such as heavy metals, PCB=s, pesticides, grease and oil (28, 34). Other types of long-term impacts include depressed levels of dissolved oxygen, accumulation of toxics, and increased eutrophication (aging of lakes) as a result of nutrients contained in the runoff. In addition, a marked increase in river and stream flow resulting from Storm water runoff may cause scouring and re-suspension and/or re-deposition of pollutants previously deposited in sediments.

Storm water runoff from transportation-related activities may contain elevated concentrations of several heavy metals (lead, zinc, iron, copper, cadmium, mercury, nickel, chromium). Concern over the release of heavy metals into the environment has led to the production of as extensive body of literature. Toxicity tests have shown that heavy metals at high concentration can cause delayed embryonic development, suppressed reproduction, inhibition of growth rates, and mortality among aquatic organisms (31). However, the ecological significance of laboratory toxicity test results are unclear because of the highly unnatural experimental conditions. Levels used in toxicity tests may be several orders of magnitude above concentrations that occur in fresh waters. In addition, the toxicity of heavy metals has been shown to vary with their chemical properties and with habitat variables, such as temperature, pH, oxygen content, and water hardness (37). Additional research is needed on heavy metals and other potentially toxic contaminants present in transportation runoff in order to adequately describe 1) the availability of contaminants, 2) water quality impacts (*indirect effects*), and 3) biotic responses to high-level, short-term exposure and low-level, long-term exposure.

Other contaminants, including nutrients (nitrogen & phosphorus), petroleum products, polychlorinated biphenyls (PCB's), asbestos, rubber, pathogenic bacteria, and pesticides have also been detected in transportation-related runoff and represent potential surface water problems. Increased nutrient loadings may cause nuisance aquatic plant growths and eutrophication. Excessive concentrations of pathogenic bacteria can prevent the receiving water from being used for recreational or water supply purposes. Kobriger et al (1983) strongly recommend that pesticides not be used on road shoulders and ditches that are adjacent to surface waters (16). The environmental impact of petroleum products, asbestos materials and PCB's at levels in roadway runoff requires further investigation.

The ability of different dust suppression materials to impact water quality varies with the type. Indiana Code IC 13-7-4-1 prohibits the application of used oil for this purpose due to environmental concerns. A variety of commercial petroleum products such as resins and asphalt emulsions are used throughout the State for dust control on industrial and mine haul roads as well as public rural unpaved roads. Because these materials are not water soluble, they are unlikely to runoff or leach into surface or ground water. Unpaved roads treated with these types of products are likely to have physical characteristics similar to paved roads. Water quality impacts should be similar to that of rural paved roads because unpaved roads are likely to receive less traffic than paved roads. Application of salt containing solutions such as calcium chloride is a second major type of dust control method. These chemicals are hygroscopic, which means that they attract moisture to the unpaved road, preventing the surface from drying out and forming dust. These chemicals are water soluble and could leach into groundwater, or runoff into surface waters if applied immediately prior to a storm event. A third class of dust suppressants are lignosulphonates. These are primarily wood processing by-products which contain high concentrations of sugars. They are water soluble and under certain conditions may runoff into surface waters. In some cases, this has caused high oxygen demand and resulted in fish kills.

For a variety of reasons, it is difficult to quantify the extent to which dust suppression is a problem for Indiana waters. Lawful application of dust suppression materials is specifically exempt from spill reporting requirements in 327 IAC 2-6.1. Also damages, such as fish kills and water quality violations, may occur several days after their application. This may happen if precipitation generates washoff after application but before the material can completely cure. The time delay between cause and effect and lack of reporting, make it difficult to trace these impacts.

Many potentially toxic materials are carried along transportation right-of-ways which either cross or are adjacent to surface waters. There is a potential for a toxic material spill which would result in as immediate short-term and/or long-term impact on the adjacent aquatic ecosystem. Indiana Department of Environmental Management (IDEM) responds to calls involving spills. INDOT is notified of spills on State routes while county road commissioners of city street departments are notified of spills on non-state roadways.

Highways, by virtue of their design, have a built-in filter strip along each side of the travel-way. This greenbelt is the right-of-way and serves as a filter for the runoff from the paved surface. The grassy right-of-way is most noticeable in the rural areas, however, also exists along sideslopes of many urban State, U.S., and Interstate Routes. These sideslopes filter out much of the contaminants from the runoff before it enters the receiving waters.

Design practices can effect the pollution generation capability of roadways. Drainage systems, fill composition, pavement materials, traffic patterns, road location and proximity to sensitive water resources can all influence the ability of the road to contribute to NPS Water Pollution. INDOT methodically includes these types of considerations in designs for state projects to the extent they are required under current regulations. INDOT has developed and is using a new Environmental Manual for Construction Activities to address these design considerations. INDOT has also begun to include some BMP's into highway projects. In the karst topographic region of South Central Indiana, fibrous sphagnum peat-sand filters were incorporated into the design and construction of a new 4-lane divided highway to protect this sensitive and unique area. INDOT has negotiated a Memorandum of Understanding (MOU) with the U.S. Fish & Wildlife Service, IDNR, and IDEM that will provide a framework for highway planning, design, bidding, construction, and maintenance practices that will protect endangered species, water quality, and other unique features of Indiana karst region.

Recommendations

1. Evaluate known impaired waters for indicators of impact from public roads for inclusion in Assessment Report. Indicators could include high levels of metals in sediments, organic compounds associated with gasoline, engine oils, and coolants, oily discoloration on water not associated with industrial discharges, and high salt levels in groundwater. Maps could also be used to identify waters in close proximity to roads which are likely to be impacted. Possible Data Sources:

305(b) Report
IDEM, Office of Environmental Response Spill Database
U.S.G.S. 7.5 Minute Quadrangle topographic maps

2. Monitor wet weather loadings to waters identified in recommendation 1. above to quantify road runoff impacts.
3. The development of further MOUs between IDEM and INDOT to protect other sensitive water resources in close proximity to roadways. IDEM should also encourage efforts to evaluate the effectiveness of BMPs, such as the fibrous sphagnum peat-sand filters, implemented by INDOT.
4. Support urban runoff projects designed to reduce pollutant loadings from street runoff.
5. Work with Office of Pollution Prevention & Technical Assistance (OPPTA) of IDEM, INDOT, American Public Works Association (APWA) to develop an educational outreach program for road designers and maintenance workers. The Northwest Regional Office (NWRO) of IDEM sponsored a workshop on salting practices in 1995 which could be carried out to other areas of the state. This could also be expanded to include other road activities which may impact water quality.
6. Over time INDOT will continue to incorporate BMPs and storm water considerations into project design and planning. They also have some oversight on projects at the county and local level, Local Public Assistance (LPA) Projects. When these efforts go beyond regulatory requirements, IDEM could work to assist INDOT in a variety of ways. IDEM could also support education and outreach efforts to county and local planners, consultants, and engineers as to the importance of including these concerns in their road projects.
7. The Joint Highway Research Project (JHRP), a cooperative venture of INDOT and FHWA working out of Purdue University, has undertaken some studies exploring options for more cost-effective highway right-of-way maintenance. Some of these, such as *New Treatment Combinations for Control of Brush and Vegetation Management along Indiana Roadsides* (FHWA 1995), and *Wildflowers for Indiana Highways* (FHWA 1996) have environmental implications. IDEM should encourage and participate in more of these types of projects.
8. Conduct outreach programs to vendors and applicators of dust control substances to educate them on practices to reduce impacts to water quality and aquatic life.
9. Ensure that the fugitive dust control plans included in industrial air permits also include provisions to prevent dust suppression chemicals from entering waterways.

Recommendations

1. Maintain frequent street sweeping programs.
2. Clean catch basins at least quarterly, consider inclusion of specially designed sediment trap catch

basins in sensitive areas. Studies have shown that less frequent cleaning has little impact on annual pollutant loadings. Also, more frequent cleaning may reduce the possibility of the removed debris being classified as hazardous waste.

3. Utilize grassed swales for drainage conveyances wherever possible. NRCS #412
4. Plan new roads to minimize runoff impacts by including extended dry detention basins, wet ponds, constructed wetlands, and infiltration devices to the extent practical. NRCS #350,#638, & #657. Indiana Drainage Handbook **5.12**-#1201
5. Plant right-of-way vegetation to act as filter strips, and to include native low maintenance vegetation. NRCS #393. IDNR #3.73. Indiana Drainage Handbook **5.8**-#804
6. Retrofit urban roads and highways with ultra urban devices such as sand filters, peat-sand filters, and prefabricated treatment devices. Some EPA approved devices include StormTreat[7], and StormCeptor[7].
7. Retrofit older highways by converting flood detention areas at interchanges to extended dry detention basins and wet ponds. NRCS #657. Indiana Drainage Handbook **5.12**-#1201.
8. Develop and enforce local litter and pet waste control ordinances.
9. Reduce pesticide and fertilizer use on right-of-ways. IDNR, Division of Forestry-Planting & Weed Control.
10. Avoid direct draining of runoff from bridge decks into surface waters by diverting drainage to land treatment areas. NRCS #362, #412, #570, #620.IDNR #3.22
11. Consider utilizing porous pavement or open paving blocks for parking lots or other low traffic areas.

Railroads

The Indiana rail system consists of forty-one (41) railroads (companies) operating on approximately 4,407 miles of mainline track. There are two railroads providing passenger service for Indiana residents with annual ridership averaging over 200,000 passengers. The majority of Indiana railroads ship three main categories of commodities; mining, industrial, and agricultural. Farm products are the State=s leading export with 27.6% of the total car loadings and 35.01% of the tonnage. Primary metals from the northern Indiana steel producing area are the second largest export. The third, fourth, and fifth leading exports are; transportation equipment, food and kindred products, and coal in carloads and in the opposite order if considering tonnages. In spite of Indiana's dominance in coal production, the major item imported by rail is coal from Wyoming and Colorado. Second and third on the State=s import list are shipments of chemicals and allied products and petroleum and coal products. Together these two represent 19% of the car loadings and a little more than 17% of the imported tonnages. These chemicals and petroleum products are of concern when considering NPS Water Pollution. Table 7 shows the amounts of different commodities shipped by rail in 1985 and 1993 to gain a perspective on the trends in railroad transportation in Indiana. Indiana accounts for only about 500,000 originated carloads annually and the nation originates about 20 million carloads, or 2.5% of the total (3).

Maintenance practices on railroad right-of-ways are also a concern when NPS Water Pollution is considered. Vegetation control, drainage ditch clearing, and cross-tie replacement are the only three maintenance practices used regularly on railroad right-of-ways. The rail terminal yards are regulated by the National Pollutant Discharge Elimination System (NPDES) as industrial facilities.

TABLE 7. Quantities of Products Shipped by Rail in Indiana in Carloads (3).

Products	**1985**	**1993**
Farm Products	93,477	115,561
Coal	130,333	125,501
Nonmetallic Minerals	4,096	4,256
Food and Kindred Products	35,586	37,788
Lumber and Wood Products	1,440	1,120
Furniture and Fixtures	1,240	40
Pulp and Paper Products	4,100	3,360
Chemicals and Allied Products	7,888	12,080
Petroleum and Coal Products	11,364	18,560
Clay, Concrete, Glass, & Stone	16,732	11,472
Primary Metal Products	68,428	108,712
Fabricated Metal Products	796	480
Electrical Machinery	5,488	9,840
Transportation Equipment	42,315	50,029
Waste and Scrap Materials	25,524	22,160

Analysis

Rail cars carry a great deal of potentially hazardous material throughout Indiana. These chemicals and petroleum products, if spilled could have extreme consequences on the environment. The accidental spilling of hazardous materials are covered under the spill reporting and clean-up requirements of Indiana Environmental Rule: 327 IAC 2-6-1 & -2 *Spills into Waters of State*.

Railroads annually apply herbicides to track and gravel ballast areas to control the unwanted vegetation. The purpose of the vegetation control is for employee safety, to prevent gravel bed degradation, and to maintain line-of-sight at grade crossings with roads. There is also spot applications of herbicides as needed at grade crossings and trouble areas. All herbicides application is performed in accordance with Environmental Protection Agency (EPA) regulations and by licensed applicators.

Two other maintenance practices which the railroads regularly perform are drainage ditch clearing and cross-tie replacement. The ditch clearing operation would be regulated under IDEM Article 15. NPDES General Permit Rule Program - RULE 5 *Storm Water Runoff Associated with Construction Activity* if over 5 acres of ground were disturbed. The cross-ties decay over time and periodically need replaced. The ties are replaced every 4-5 years, usually by pulling every 4th or 5th tie with minimal soil disturbance. The ties are pressure-treated with creosote as a wood preservative to help their longevity as an integral part of the track structure. It is this creosote that is of a main environmental concern, it is volatilized by sunlight. Soil testing around the in-place ties show very small amounts of creosote leaching. That which does leach penetrates the soil only a few feet. Creosote is biodegradable by the soil organisms. Waste cross-ties pass the Toxicity Characteristic Leaching Procedure (TCLP) testing as non-hazardous.

Recommendations

1. IDEM should work with the American Railway Engineering Association, to encourage educational programs for railroad right-of-way maintenance workers to improve their awareness of environmental concerns. Mr. Chris Barkin is Head of Environmental Department for the Association and can be contacted at (202) 639-2276.
2. Railroads should be educated or encouraged to file Notice-of-Intent Letters (NOIs) for ditch clearings even if less than 5 acres total ground is disturbed.

Airports

Indiana has a total of 673 airport facilities, 556 private and 117 public-use. Out of the 556 private facilities, 414 are air strips, and only a few of these are paved. Out of the 117 public-use facilities, 109 are airports, with 90 of them having paved surfaces. The 556 private facilities are of no significance since the majority are turf strips with very minimal aircraft traffic use. The 117 public-use facilities are categorized as industrial facilities under the NPDES and are regulated in accordance with this criteria. The storm water discharge from these facilities is periodically sampled and tested for contaminants.

Analysis

The four largest airports in Indiana provide commercial air-passenger serve and also are regulated under NPDES. These airports use deicing chemicals on the departing aircraft in snow and ice conditions. The chemical is usually ethylene glycol and must be totally recovered from the application area and reused, recycled, or otherwise disposed of and not allowed to drain from the facility. The larger airports also apply urea to their runways, taxiways, and aprons to melt snow and ice. Salt is strictly prohibited from airports due to its corrosive effects on the aircraft. Corrosion of any part of an aircraft would have catastrophic consequences. The urea runoff from the runways and taxiways is caught in the grass along the edge of pavement and acts as a fertilizer in the Spring by the grass. Very little urea is used on aprons and is diluted in the storm water drainage system.

Aircraft are, by regulation, meticulously maintained on a regular basis to assure safety. This maintenance minimizes leaking and spillage of petroleum, grease, and oil from the aircraft, and virtually eliminates contaminants from the storm water runoff of airports. By virtue of their design, airports also have vast expanses of grass which acts as a filter for surface runoff.

Recommendations

No recommendations are made in this document for airports in regards to NPS Water Pollution which go beyond what is already standard practice.

BOATING

The ever increasing usage of power boats for recreational purposes poses a potential threat to surface water quality. Commercial boats, barges & barge tugs, or ships may effect the water quality of the Ohio River and Lake Michigan. These boating activities threaten water quality in several ways; shoreline erosion, introduction of pollutants, and re-suspension of bottom sediments.

As operation of power boats becomes a more popular pastime, increasing numbers of boaters utilize public waters for recreational purposes. Wakes created by the boats increase shoreline erosion, particularly where protective wetlands have been filled or excavated. Imposition of speed limits and restrictions on operation near shores help to reduce the problem, but enforcement can be difficult because of the limited number of conservation officers available to patrol public waters. In addition to turbidity caused by the erosion, the unusual water movements could be very disruptive to fish and other organisms attempting to inhabit or reproduce in near shore areas. Propeller wash from boats can itself be damaging as nutrients associated with bottom sediments are re-suspended in shallow water and become available for nuisance algae and plant production.

There is little documentation of the biological effects of underwater boat engine exhaust discharges, but the potential for cumulative impacts increases constantly as more and more boaters utilize public waters. Lakes, as confined systems, could accumulate many of the toxicants present in exhaust products, such as lead and other heavy metals. Various hydrocarbons and other combustion by-products could conceivably have detrimental effects on the respiration of aquatic organisms.

Recommendations

1. Promote research to evaluate the impacts from engine exhaust and ascertain damage caused by sediment/nutrient re-suspension and erosion.
2. If necessary, establish stricter speed limits and restrictions on near shore operations.
3. Provide more stringent enforcement of boating regulations, if appropriate.

Best Management Practices

- Utilization of erosion control plantings and protection of the vegetated areas from boat traffic. IDNR #**3.1**. NRCS #580. Indiana Drainage Handbook #**5.5 & #5.11**
- Provision of stream bank protection with rock rip-rap on graded slopes not steeper than 2:1. IDNR #3.16. NRCS #580. Indiana Drainage Handbook **5.5**-#510
- Construction of retaining walls to protect slope bases in areas where excessively steep slopes are present. NRCS #580. Indiana Drainage Handbook **5.5**-#5.11, #5.12, #5.13, #5.14, & #5.15.

CONSTRUCTION

Stream channelization, dredging, land clearing, streambank modification, channel relocation, as well as side-ditch construction can all be involved in road and bridge construction and other transportation facility construction. These are all activities that typically involve earthmoving and/or excavation work, removal and destruction of large areas of vegetative cover, utilization of different types of mechanical equipment and their associated fluids, and the use of chemicals to restore vegetative cover. These common practices are potential nonpoint sources of water pollution.

During clearing, excavation, embankment placement, soil is exposed. This material, particularly on sloped surfaces, is highly susceptible to erosion prior to revegetation. Of particular concern are the many road construction projects that occur each year throughout the State. Typically, such projects extend for thousands of feet, even miles, leaving extensive roadbed, berm, and embankment surfaces exposed for significant periods or time. Soils eroded from these sites enter roadside ditches which drain into rivers, lakes, and streams. The eroded material can be considered as a pollutant, as well as serving as a vehicle to transport other types of pollutants into the surface waters. Eroded material can carry contaminants into streams, increase turbidity, degrade aquatic habitat, and otherwise reduce water quality. It is estimated that annually 17 million tons of soil erodes from streambanks, gullies, roadsides, and construction areas in the State. The continued erosion of soil and resulting sedimentation of Indiana's waters will impair use of the water resource and cause deterioration of water quality.

Construction of transportation facilities can have an effect on the natural or geologic erosion process by exposing disturbed soils to precipitation and to surface storm runoff. Shaping of land and stream channels alters the soil cover and the soil in many ways, often detrimentally affecting drainage and storm runoff patterns and, eventually, stream and stream flow characteristics. Activities such as channel dredging, clearing and snagging, channel relocation or modification, and equipment movement within the stream result in the disturbance of stream bed materials and sediments. Much of this material becomes suspended in the water and can move downstream, carrying contaminants with it. There have been numerous cases of sedimentation problems in the State's rivers and streams as a result of upstream construction activities. However it is difficult to assess the amount of material which is dislodged as a result of channel work, and determine the extent of the problem.

Construction projects in and adjacent to the State's waterways involve the use of a number of chemical substances which may ultimately find their way to the waterways and serve as nonpoint sources of pollution. Typically, the chemical substances of concern would include the fluids contained in mechanical equipment such as fuel, lubricants, engine coolants, etc.; pesticides and fertilizers used to restore vegetative cover; paint; asphalt; and sealing materials. While the amount of any individual substance entering the stream may be small, the aggregate amount of all chemicals on an individual job site may be a significant source of pollution. Since the chemicals are usually present in liquid form, any spillage may contaminate nearby waters. In addition, since the chemicals are often placed or stored on exposed soil, some of the spilled material can be transported to nearby rivers and streams via soil erosion.

All construction projects inherently include certain activities which affect water quality, but are not as visible or easily measured as sedimentation and chemical pollution. These are activities which can indirectly impact the biological components of a stream. The removal of streambank vegetation, dredging, and soil erosion all can contribute to changes in water temperature, decreases of oxygen levels, or the loss of in-stream habitat. While perhaps not commonly thought of as forms of pollution, these changes can seriously affect aquatic habitat and degrade water quality, *indirect effects*.

The Indiana Department of Environmental Management, under it *water rules* has established **ARTICLE 15. NPDES GENERAL PERMIT RULE PROGRAM, Rule 5. Storm Water Runoff Associated with Construction Activity,** which states in the purpose section, 327 IAC 15-5-1: *"The purpose of this rule is to reduce pollutants, principally sediment as a result of soil erosion, in storm water discharges into surface waters of the State from sites where construction activity disturbs five (5) acres or more of the site. However, in contemplation of recent federal court decisions, persons with sites greater than one (1) acre but less than five (5) acres are invited to comply with this rule as well."*
The Indiana Department of Transportation requires that erosion control measures be included as an element of the contract on all current highway and airport construction projects to meet Rule 5 above. These measures are comprised of an erosion control plan which may include ditch check dams, either straw bales or rip-rap, plastic filter cloth, sediment basins, etc. Standard specifications require stockpiling topsoil to be re-spread after construction is complete for the re-establishment of vegetative cover. Contractors are also required to prevent sediments from entering streams. Standard specifications and special provisions address sod, seeding, and mulched seeding, agricultural lime, pesticides, and fertilizers used to re-establish vegetative cover.

All federal aid projects must conform with requirements imposed by the National Environmental Policy Act. This involves a systematic assessment of all environmental impacts including water quality. Projects are reviewed by a number of state and federal agencies for environmental effects and mitigation measures.

Roadway development results in the removal of vegetative cover and sometimes exposing impervious surfaces adjacent to lakes, rivers, streams, and wetlands. Intense rainstorms will result in rapid runoff, sudden peak flows, and altered water levels. Fraser (1972), in a review of stream flow, considered flow velocity to be the dominant physical factor affecting stream life (8). Stream flow velocity will influence fish food and habitat availability through its impact on invertebrate life, re-suspension of bottom sediments, stream turbidity, bottom channel erosion and sedimentation (5). Most stream dwelling organisms are adapted to a particular flow velocity and any major change in velocity may alter habitat availability. Sediment particles contained in roadway runoff, upon delivery to surface waters, will influence water turbidity, temperature and act as a carrier of heavy metals, pesticides and nutrients. Major increase in the suspended sediment load of streams has been shown to result in reduced survival and hatching of fish, decreased aquatic insect production, and a reduction in substrates necessary for aquatic plants (13, 15, 36). In waters where quality fisheries are to be maintained, even temporary high concentrations of suspended solids should be prevented, especially in trout and salmon spawning grounds (1).

Pursuant to Indiana Code 13-2-22, the Indiana Department of Natural Resources must approve any construction, excavation, or filling within the floodway of any river or stream in the State. As a condition of these approvals the Department of Natural Resources generally requires that disturbed areas be protected from erosion during construction and be suitably re-vegetated or provided with permanent protection immediately upon completion. The Soil and Water Conservation District Act (IC 13-3-1) requires the State Soil Conservation Board to coordinate the erosion and sediment control portion of the federal Water Pollution Control Act, and other erosion and sediment reduction programs that affect water quality, in cooperation with state and federal agencies and through soil and water conservation districts. The issue of soil erosion and sedimentation is being addressed by the State through the AT by 2000" program. Administered by the Department of Natural Resources Division of

Soil Conservation, AT by 2000" provides technical and financial assistance for *lake enhancement* for public lakes and erosion control structural measures on private land where resulting sedimentation is detrimental to the public good.

Regulatory controls over road construction projects which are not under contract to, or not funded by state or federal entities are minimal or non-existent. Portions of such projects located within floodways of the State=s rivers and streams would require approval in accordance with IC 13-2-22. As a part of the permitting process, erosion control measures could be required by condition; however, the conditions would be applicable only to portions of the project. Any erosion control measures implemented on the remaining portions would be included at the discretion of the contractor performing the work.

As apart of the IC 13-2-22 permit process, projects are reviewed with respect to channel alignment, capacity, and construction. Approvals are conditioned to avoid creating channel alignments highly susceptible to erosion and scour, prevent undue velocity increases, and minimize habitat loss.

During work in or adjacent to water courses, it is often necessary and important to shape the banks to ensure a smooth transition to the newly constructed portion. For instance, in some situations, bridge structures of shorter length are specified to minimize channel bank and bed disturbance. However, a reduction in bridge size can cause an increase in stream velocity, resulting in scour along the bridge foundation and potential collapse of the structure.
State and federal projects attempt to limit bank shaping to an elevation no lower than one foot above low water level, and when possible, require the installation and maintenance of sediment traps during construction. These conditions are typically included as a part of IDNR approvals pursuant to IC 13-2-22. The INDOT limits the fording of streams by construction equipment; where necessary, a work bridge or a rock crossing of clean rock fill is required to prevent undue erosion. IDNR, IDEM, U.S. EPA, and the U.S. Fish and Wildlife Service all review stream-related construction projects subject to the U.S. Army Corps of Engineers Section 404 permitting, and suggest ways in which the projects can be improved to limit erosion and sedimentation.

There is only limited data on the annual number of in-stream construction projects and the amount of sedimentation which results from them. Many projects which are not under contract to or funded by the State or federal entities are not monitored for compliance during construction. Few projects are examined after construction is completed. Minimal data exists in Indiana which document the impacts of sediment on downstream water quality and aquatic habitat.

Few contractors have special provisions or standard specifications requirements in their contracts to ensure that equipment is in good working order to minimize the spillage and leakage of pollutants. Appropriate special provisions could include requiring the use of flotation booms in an effort to prevent removed paint and new paint particles or petroleum products from floating downstream. Sealing materials, as well as surface debris, can be prevented from entering streams by using simple maintenance practices such as preventing spillage or leakage, and any spilled materials can then be removed using basic hand tools.

NPS Water Pollution during construction has not historically been an issue which has been addressed by the conditions in IDNR Construction in a Floodway Permit. When a permit application involves the construction of a facility which could store chemicals, conditions are generally added which would insure that these chemicals would not enter the stream. There are currently no known data available which could be used to assess the magnitude of the pollution threat from on-site chemicals during construction activities.

There are minimal scientific data available regarding the effects of construction variables on specific streams. IDNR permit applications are reviewed for the general effects on fish, wildlife, and botanical resources by biologists from the Division of Fish and Wildlife. Permits are then conditioned to prevent or minimize adverse impacts to fish, wildlife, and botanical resources or provide mitigation for the loss of these resources. Typical conditions include restrictions on the amount of vegetation removed, requirements for the use of one-sided construction, imposition of seasonal time constraints on in-channel excavation work, and requirements regarding maintenance of buffer strips between project sites and stream banks.

As part of state and federal construction project approval, extensive environmental reviews are conducted during the early stages of planning. Both the U.S. Fish and Wildlife Service and IDNR Division of Fish and Wildlife review the projects for potential impacts to fish, wildlife, and botanical resources such as wetlands. In addition, IDEM reviews many of the project proposals for potential water quality impacts, including effects which the project may have on wetlands, fish and other aquatic life. The environmental documents are prepared, in part, to address the concerns of the reviewing agencies. When possible, mutually agreed upon mitigation measures are incorporated into the project design. Any restrictions imposed by the U.S. Army Corps of Engineers, IDEM, or IDNR through their permit process are also incorporated into the project plans. INDOT has established an Environmental Services Section in their Preliminary Engineering and Environment Division with a Professional Engineer to field check construction projects and evaluated compliance with environmental permits. This engineer makes recommendations to the Project Engineers and Supervisors to improve performance in reference to the environmental permits.

Designers of transportation facilities use the following reference documents to assist them in developing erosion control plans and designing erosion control measures that adequately comply with the requirements of RULE 5:

INDOT - *Temporary Erosion and Sediment Control Guidelines*
IDNR - *Indiana Handbook for Erosion Control in Developing Areas*
IDNR - *Indiana Drainage Handbook*
HERPICC - *A Model Ordinance for Erosion Control on Sites with Land Disturbing Activities* (Highway Extension and Research Project for Indiana Counties and Cities)

Recommendations

1. Conduct research and develop a program to assess the magnitude of the erosion/sedimentation problem as it relates to flood control, drainage, road construction and bridge projects which affect the State's waters. Also evaluate the short-term and long-term impacts this problem has on the water quality and how it impacts the environment and society. Conduct cost-benefit analysis on this problem.
2. Undertake research to evaluate the effectiveness of current techniques to control sedimentation effects. Prepare guidance documents presenting the results of the research and make recommendations to the current guidance documents mentioned above.
3. Conduct research to assess the magnitude of the chemical contamination problem as it relates to

flood control, drainage, road and bridge construction projects. Also evaluate the short-term and long-term impacts chemical contamination has on water quality and how it impacts the environment and society. Conduct cost-benefit analysis on this problem.

4. Conduct a pilot project to identify and assess the *indirect effects* of construction and channelization on water quality. Conduct cost-benefit analysis on this problem.

5. Continue to develop educational programs which will make the public and contractors aware of the fact that erosion/sedimentation, construction chemical spills, and general construction activities can contribute to NPS Water Pollution.

6. Encourage consideration of alternatives, such as limited clearing and snagging, which would accomplish project goals but minimize channel disturbance.

7. Encourage alternatives that will minimize clearing of forest cover and buffer areas.

8. Establish criteria to be incorporated into all State and Local bridge and highway contracts and permits regarding use, disposal, and containment of chemicals at construction project sites.

9. Actively enforce laws and regulations which prohibit the use of non-approved chemicals and pesticides in and adjacent to the waterways.

10. Encourage the installation of boulders, gabions, rip-rap riffle areas, forest riparian buffers, and the terracing of stream bottoms where conditions warrant. Conduct cost-benefit analysis on these practices.

11. Continue to require permit holders to utilize one-sided construction where possible, and minimize removal of trees and other protective vegetation adjacent to affected streams.

Best Management Practices

- Planning the project to minimize impact to the particular topography, soils, waterways, and natural vegetation at the site. NRCS #570
- Application of erosion control practices: keeping soil covered with temporary or permanent vegetation or with mulch material. NRCS #327 & #484. IDNR #3.11, #3.15, #3.17, #3.18. Indiana Drainage Handbook #**5.11**.
- Exposing the smallest practical area for the shortest possible time.
- Application of sediment control practices
- Implementation of a maintenance program to assure proper operation of erosion control measures.
- Designing projects so that stream bed and bank disturbance is minimized.
- Requiring the storage of contaminants at a safe distance from any water bodies.
- Prohibition from changing or draining fuels, lubricants, or coolants in or near water bodies. When changed, old fluids should be required to be stored in containers and promptly removed from the site. IDNR, Division of Forestry, Proper Use and Disposal of Fuel, Lubricants, and Trash.
- Requiring containment structures or measures to prevent any spilled fluids from contaminating surface or ground water.
- Properly maintaining mechanized equipment to prevent fluid leaks and spills.
- Requiring correct usage of pesticides and fertilizers.
- Minimization of streambank and lakeshore vegetation and forest cover removal. Revegetate as soon as practical to provide shade for the water and habitat for the fish and wildlife. IDNR, Division of Forestry, Riparian Management Zones.
- Preservation of existing riffles and pools, when possible. IDNR #3.76. Indiana Drainage Handbook #706
- Retention of low flow channel in modified streams.
- Utilization of boulders, gabions, rip-rap riffles, and terraced stream bottoms in reconstructed

channels to provide water aeration and biotic habitat. IDNR #3.71, #3.72, & #3.76. Indiana Drainage Handbook **5.7**-#706 & **5.12**-#1202.

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MINERAL EXTRACTION

ACTIVE SURFACE AND UNDERGROUND COAL MINING

Issue

Currently (1996), there are an estimated 50 active surface coal mines and two underground mines in Indiana. Due to various economic forces the number of surface mines is expected to decline in the future.

Active surface and underground coal mines subtly or substantially alter the physiography, surficial geology, and vegetation of the mine site. These alterations can have deleterious affects on ground and surface water flow paths and chemistry on site and down gradient from the site. Surface runoff from surface mines can erode newly exposed materials causing an increase in sediment load in surface water bodies. This sediment can adversely affect aquatic life as well as choke streams and fill lakes.

Both surface and underground mining will alter water chemistry through oxidation, dissolution, precipitation, and ion exchange reactions. Sulfide oxidation results from exposure of layers of bedrock containing the minerals pyrite and marcasite to atmospheric oxygen contribute increased acidic mineralization, particularly sulfate and transition metals such as iron, manganese, and zinc, to both surface and ground water. These metals will remain in solution in ground water, whereas oxidizing surface water conditions generally produce oxyhydroxide precipitates of iron (yellow and red) and manganese (black). Dissolution of carbonates and gypsum adds calcium, magnesium, and sulfate and can add to the total dissolved solids content of waters in the drainage basin. Ion exchange typically increases sodium content in ground water.

The above mentioned alterations are inevitable products of mining activities, but a good understanding of the premining hydrogeologic setting and potential chemical reactions that result from the mining process give the mining companies the information they need to minimize harmful effects on the environment. In fact, the application of technically sound mining and reclamation techniques assure that the potential harmful effects mentioned above will be minimal.

Analysis

In 1977, Congress passed the Surface Mining Control And Reclamation Act of 1977 (SMCRA) requiring extensive reclamation of mine sites including the minimization of impacts to ground and surface waters. Indiana received federal approval to implement the state counterpart program in 1982.

The Indiana Department of Natural Resources Division of Reclamation (IDOR) regulates ground and surface water through the Indiana Mining and Reclamation regulations 310 IAC with oversight by the Federal Office of Surface Mining (OSM). Six months of baseline surface and groundwater sampling is required to characterize the pre-mine water quality and quantity. Monthly site inspections by IDOR are conducted that must consider mining impacts to ground and surface water.

All runoff from a mine site is regulated. Provisions within 310 IAC 12 state that surface mining activities shall be planned and conducted to minimize changes to the prevailing hydrologic balance in both the permit area and adjacent areas and to prevent material damage to the hydrologic balance outside the permit area in order to prevent long term changes in that balance. The rules further state that each person who conducts surface mining activities shall emphasize mining and reclamation practices that prevent or minimize pollution. This section of the rules applies to all mining activities, not just drainage through a point source.

As provided by the regulations, minor areas such as haul roads, small drainage areas, diversion ditches, or siltation structures may not report to sediment basins. These areas are required to use best management practices such as rip rap, straw dikes, check dams, mulch, dugouts, or other measures to reduce overland flow velocity, reduce run-off volume, or trap sediment to control run-off. These areas on average will constitute less than 10 percent of the drainage area and should not be significant in terms of discharge volume. The operator must demonstrate that the alternative method of drainage control is sufficient to preclude contributions of suspended solids to stream flow off the permitted area prior to approval of the alternative method by the Inspection staff of the IDOR.

IDOR requires monitoring of installed groundwater monitoring wells until bond release has occurred, at which time IDOR must make the finding that adverse impacts to the hydrologic balance are not occurring. Mineralization of ground and surface water in active or recently abandoned mines appears to be minimal. Surface and ground water that flows through these mines can be and is generally used for livestock watering, irrigation, recreation, fishing, wild life habitat and when treated may be used for drinking water. Research and monitoring data from surface mines demonstrate that by disturbing or breaking up the material that overlies the mined coal seams the volume of groundwater available for beneficial usage is increased.

In addition, Indiana Department of Environmental Management (IDEM) regulates surface runoff at active mines through the NPDES program under the provisions of 327 IAC 15-7 which provides effluent limitations for sediment basin outfalls. Wet weather base flow is also monitored at these locations due to the placement of sediment basins low in the affected watersheds. A recent revision to IDOR hydrologic balance protection rules requires each application to contain a surface water monitoring plan distinct from the NPDES provisions. Monitoring locations are determined on a permit by permit basis. The collection of downstream baseline data and continued downstream monitoring until bond release will, in effect, monitor all water discharges from the permitted area, not just those that pass through a point source.

Coal preparation facilities not located at or near a mine site are also required to obtain a surface coal mining permit from IDOR. Coal loading facilities which are not located at or near a mine site are not required to obtain a surface coal mine permit from IDOR. These facilities obtain required permits from IDEM including Facility Construction and NPDES Permits; therefore, discharges from these facilities which are not regulated by IDOL must meet applicable IDEM requirements.

The Indiana Division of Water registers significant water withdrawal facilities. The United States Army Corps of Engineers issues permits under section 404 of the clean Water Act for disturbances in wetlands.

Mined property returns to the land owner once the mine site has been reclaimed and bond release has been achieved. At this point the NPS management plans for agricultural lands should apply.

Recommendations

1. Promote awareness of and encourage IDOL mine inspectors and mine personnel to identify and control problematic run-off that is not directed to a sediment basin.
2. Educate owners of reclaimed lands about the NPS agricultural management plan so they fully understand the use limitations of this land.
3. Encourage continued oversight by OSM/IDOL so that the effects of mining operations will be continually appraised.
4. IDOL should review and approve mine plans and inspect to determine if plans are implemented and are functioning as proposed.
5. Consider consequences of placing non-mine wastes in active mines and conduct scientific studies to determine efficacy of these activities.
6. Consider a public education program to support coal ash placement in active mines.

OIL AND GAS PRODUCTION

Issue

Oil and gas have been produced in quantity in Indiana since the late 1800's. Production has been largely concentrated in two parts of the state. Early production was from the Trenton Field in the east central part of Indiana, whereas current production is from the southwest. There are scattered wells in much of the remainder of the state.

There are approximately 7,500 oil, 780 gas and 1,400 Class II injection wells operating in Indiana. In addition, there may be as many as 70,000 abandoned wells of which more than 1,200 have been inventoried. The Division of Oil and Gas maintains a field staff of ten inspectors. This means that on the average each field inspector is responsible for 900 active wells and more than 100 inventoried abandoned oil and gas related wells. These figures are averages and do not reflect actual distribution of wells in each inspection district.

There are several potential sources of contaminants that are the result of production of oil and gas from wells. The most important of these are: 1) surface infiltration of oil or waste fluids through the unsaturated zone; 2) subsurface migration of oil and waste fluids from underground reservoirs into fresh waster horizons through faulty wells; and 3) runoff to surface water bodies from spills of oil and waste fluids.

Little data exist to assess the full potential of these problems, yet each may pose a threat to the waters of the state.

Surface Infiltration

Surface waste impoundments, primarily abandoned impoundments, are an identifiable source of potential contamination. Improper construction and usage, as well as hydrogeologic factors, may allow waste to flow through the unsaturated zone into the water table. Additionally, although good hydrogeologic data are generally not available to evaluate the sites, the information that is available suggests that surface impoundments may in some cases actually intersect the water table; thus providing a means for direct and rapid infiltration of contaminants into the groundwater system. From the total numbers of impoundments in use, as well as the lack of specific construction criteria, it is likely that shallow groundwater contamination from abandoned brine and active drilling fluid pits does occur.

Subsurface Migration

While not as conspicuous as infiltration from impoundments, subsurface migration through abandoned or new wells may present a greater threat to groundwater. Because such contamination is often unexpressed at the surface it may go unnoticed until a drinking water supply is contaminated. Many old wells were inadequately constructed or plugged. Until these wells are identified, categorized as to threat, prioritized, and properly abandoned, some will continue to present a threat to groundwater. Present regulatory controls minimize this threat by requiring that adequate construction and plugging methods and materials be used for new wells. However, this does not eliminate the problem. Subsurface geologic factors such as structure and stratigraphy also influence fluid migration. In addition, mechanical factors such as casing degradation, cement washout and packer failure can contribute to the migration of fluids into Underground Sources of Drinking Water (USDWs)

Flooding or pressurization of the producing zone may force reservoir fluids into fresh water aquifers through unplugged or poorly plugged abandoned wells. A digitized location database would provide producers and regulators with a means of determining where to look for possible contamination problems. Guidelines could be developed to help producers recognize and deal with this potential problem.

Surface Spills

Site specific surface spills of oil and waste fluids present the lowest risk to water resources for two reasons: 1) spills are highly identifiable and 2) cleanup measures can be instituted that are both rapid and effective.

In addition to site specific waste spills the improper surface disposal of brines via dumping also poses a threat to surface and groundwater. Some operators dispose of brines by spraying them into ditches. Unregulated disposal of the wastes can have immediate and long range effects on fish and wildlife. While the extent of this practice is unknown, it does have the potential to adversely affect potable water supplies and fish and wildlife resources.

Analysis

Under the authority of IC 14-37 rules have been promulgated to regulate the safe production of petroleum and are implemented by IDNR Division of Oil and Gas. These rules are embodied within 310 IAC 7-1 and 7-1.5 and are designed to ensure that no significant contamination of USDWs or surface waters occur as a result of oil and gas operations.

Additionally, the Department of Environmental Management implements controls to prevent contamination from unauthorized surface discharges under 327 IAC 2.

Recommendations

1. Develop and implement rules for siting, construction and monitoring of surface impoundments.

2. Encourage the utilization of tanks for waste fluid storage.

3. Implement a continuing education program to ensure that the most current technology and practices are used by operators to prevent surface and groundwater pollution.

4. Develop an orphan sites management program and conduct an inventory of abandoned and orphaned wells throughout the state.

5. Conduct an inventory and environmental assessment of existing and abandoned oil and gas related fluid impoundments throughout the state. Include closure plans for abandoned pits within the framework of the orphan sites management program.

6. Develop a Memorandum of Agreement between the Division of Oil and Gas the Department of Environmental Management related to the regulation of oil and gas operations.

7. Explore alternative options to the current bonding provisions. This should include an examination of the value of instituting a Bond Pool for the purposes of distributing environmental risk and maintaining a healthy Environmental Fund

8. Conduct an audit of the current oil and gas rules to determine their adequacy, effectiveness, and appropriateness.

9. Continue to actively enforce the existing oil and gas rules with special emphasis on secondary recovery operations until revised rules are implemented.

10. Promote cooperative enforcement efforts between IDEM & IDNR.

MINING AND PROCESSING OF OIL SHALE

Issue

Although there is no current mining or processing of oil shale in Indiana there has been some interest in this activity in the past. Interest would be revived by changing economic and energy resource conditions; therefore, it is important that guidelines be in place for this resource development category.

In areas of southeastern Indiana the new Albany Shale (Devonian and Mississippian), a predominantly brownish-black shale and in certain southwestern Indiana Pennsylvanian shales, are at or near the surface; under favorable economic conditions the organic-rich intervals of these shales could be utilized as sources of shale oil and/or hydrocarbon gases. The impact of an oil shale mining and processing operation on surface and ground water quality is dependent on the nature of the shale and the retort process used. The major concern about potential pollution from mining process wastes is the production of iron, sulfate and acid by weathering of exposed pyrite. A secondary concern is pollution by trace metals and organic components that occur naturally in the shale and that are liberated by its processing. Stockpiles of raw material (usually crushed and sized shale), which could cover large areas, could be nonpoint sources of pollution if runoff is permitted to drain into adjacent waters. More likely nonpoint sources could be areas of strip mines left open to weathering. In addition, if fines left after crushing the mined shale are dumped openly, or if spent shale remaining after retorting is dumped openly and carelessly, pollutants similar to those resulting from weathering of wastes from mining and processing of raw coal could be produced. Leachate from stockpiles of raw shale may have a low pH and elevated levels of sulfate and trace metals. The nature of the leachate from the spent shale will be dependent on the retorting process used, since each type is responsible for the release of different levels of certain elements. Geographic location of the resources may have some effect on leachate composition. The effect of processing is beneficial, from the disposal aspect, since the leachate becomes more alkaline.

Analysis

Several methods can be used to mine and/or process shale: (1) surface mining and retorting of the shale, (2) subsurface mining and surface retorting of the shale, and (3) in situ retorting with recovery of oil and/or hydrocarbon gases by pumping. Not only could more than one type of mining method be employed, but most certainly more than one retorting technique will be used if an oil shale industry is developed in Indiana. Surface and subsurface mining of oil shale for surface retorting has the potential to produce nonpoint source pollution similar to that associated with coal production.

In situ retorting of shale with recovery of oil and/or hydrocarbon gases by pumping would require permission to operate a Class V injection well. Indiana does not operate a comprehensive program of underground injection control (UIC), so primary enforcement authority for Class V wells currently rests with the USEPA under the authority of the federal Safe Drinking Water Act of 1974 and the amendments of 1986.

Recommendations

1. Determine chemical constituents that are statistically elevated by mining and processing of Indiana oil shale in order to establish criteria that can be used to (2) identify NPS pollution by oil-shale mining activities and (b) set effluent limitations.
2. Determine whether some sediment and toxic effluent control techniques produce effluents that should be considered point source discharges, and should be regulated accordingly.
3. Monitor and regulate the quality of all surface and groundwater associated with shale loading facilities that are not part of a permit area. Obtain approval of the U.S. Department of Interior Office of Surface Mining to regulate these facilities under the Division of Reclamation's authority.
4. Consider the advantages of state primacy for regulation of Class V injection wells.
5. Conduct studies to determine the chemical composition of surface and ground water in the areas of potential shale developments to provide background monitoring information.
6. Guidelines for handling of retort wastes should be based on the type of retort process employed.
7. Assemble a Geographical Information System data base that includes information describing locations of oil shale mines, surface and subsurface retorting facilities, refuse deposits, leading and transfer stations, IDNR wells of record (for ground water monitoring), background ground water sites, effluent sampling sites.
8. Require NPDES review of each mining/retorting operation.

CHAPTER SEVEN: SURFACE AND UNDERGROUND MINING OF THE NON-ENERGY MINERAL RESOURCES (LIMESTONE, GYPSUM, PEAT, AND SAND AND GRAVEL)

The nonpoint source pollution potential of Indiana's significant limestone, gypsum and sand and gravel mining activities is evaluated in this section. Limestone mining is both a surface and an underground activity whereas gypsum is mined underground and sand and gravel extraction is exclusively a surface activity. The following is a discussion of limestone and sand and gravel mining activities and suggested management practices that minimize pollution potential for these operations.

Surface mined mineral resources comprise a major part of Indiana's non-energy mineral industry. Dredging, pit excavation, and quarrying are the major techniques used for surface extraction of non-energy minerals in the state. If existing regulations and responsible management practices are ignored, all three methods could cause nonpoint source pollution.

Dredging is the removal of a non-energy mineral resources from below the surface of water using a machine called a dredge. Dredges are normally associated with extraction of sand and gravel from the bottom of lakes, reservoirs, rivers, streams or pits developed specifically for that purpose. Material on the bottom of the body of water is loosened by a cutting head attached to the end of a suction line that draws the loosened material through the dredging machine and a pipeline that transports the materials, along with great quantities of water, to a processing plant. The processing plant separated the sand and gravel into various sizes using the water to wash the final product.

Pit excavation, also associated with sand and gravel production, is the removal of non-energy mineral resources from either a bank of naturally occurring materials that exists above the water table with and end loader, or from below the water table with a dragline or excavator. This material is stockpiled when extracted, to allow the excess water to drain out of the material prior to processing.

Quarrying is the removal of the non-energy mineral resource limestone, both from underground mines and surface mines. Quarrying requires drilling and blasting. Limestone is quarried as an aggregate for use in the construction industry, as an agricultural lime, and as a dimension stone. The production of these products requires that holes be drilled in naturally bedded carbonate formations. Blasting agents are placed into the holes and detonated to fracture the bedded materials into a size that can be further processed.

Fines, both valuable and waste, are produced from the drilling, blasting and additional processing that takes place in all of the above operations. These fines must be properly handling to prevent siltation problems. Control of runoff, settling basins, and other best management practices are effective in preventing fines from entering surface waters.

Active underground limestone and gypsum mines supply these high place-value mineral resources to the market in Indiana. These non-energy mineral extraction operations create substantial cavities that may alter the local hydrology. This is considered when permits are issued for water discharges. Without exception water discharges from these operations are point source and as such should be permitted. Any operation associated with underground mining that would move the production operations to the surface would fit within the category of surface mining and present the same concerns.

Analysis

Existing State Laws, through the Indiana Department of Natural Resources and the Indiana Department of Environmental Management, and Federal Laws, through the Environmental Protection Agency, the Army Corps of Engineers, and others, regulate the controlled discharge of water from the processes associated with the extraction of the non-energy mineral resources of Indiana. They also control activities that take place in flood plains and may have an influence on nonpoint source water pollution considerations. Point and non-point source pollutants are considered prior to the issuance of point source discharge permits.

Most products in the industry make every effort to control nonpoint source discharges with voluntary efforts. These efforts are expended to comply with existing regulations, and to eliminate the need for additional regulation. Most of the producers of non-energy mineral aggregates in Indiana belong to the Indiana Mineral Aggregate Association (IMAA), the National Aggregates Association (NAA), and the National Stone Association (NSA) which are active in working with regulatory agencies, on a State and National level, to assure cooperation between the regulators and the regulated.

Recommendations

1. Continue to work with major producers to avoid environmental problems.
2. Concentrate resources on producers who have been identified as having nonpoint source water pollution problems.
3. Address issues of small producers by identifying, communicating with, and educating them.
4. Locate abandoned mines and identify those that may pose problems (illegal dumping and potential erosion) and identify ways to solve if this is a problem.

All Limestone and Sand and Gravel Mining

- Limit the disturbance to the smallest area possible in any given time period
- Implement erosion control and restoration of disturbed areas with revegetation as quickly as possible
- Control storm water runoff on site so that discharged water flows through the existing permitted discharge locations

CHAPTER EIGHT: INFORMATION/EDUCATION RELATING TO NPS POLLUTION

Nonpoint source pollution information/education efforts are fragmented throughout the state of Indiana. Various stakeholders are filling in pieces of the puzzle, but their outreach efforts are not being coordinated. As stakeholders strive to educate both each other and the public, this fragmentation is resulting in duplication of efforts, as well as gaps in information.

Responsibility has not been taken for statewide coordination and planning of nonpoint source information/education. Efforts are necessary to ensure that all audiences and information are addressed. Training and the dissemination of information needs to be coordinated among both the formal channels of established education and informal channels to the general public. Coordination is also necessary to integrate nonpoint source pollution curriculum into schools. Planning and coordination is also critical to follow up and evaluate the success of these programs.

The implementation of information/education programs requires increased commitment of stakeholders, both in time and money. Increased sources of funding need to be secured to insure statewide results. Stakeholders need to be educated about where to find these sources, and how to obtain them.

Analysis

There are several roadblocks to overcome in education about nonpoint source pollution in Indiana. A lack of knowledge exists about how the various sources of nonpoint source pollution contribute to the problem. Myths need to be challenged, and the cumulative effects of individual activities need to be addressed. This involves changing perceptions of both stakeholders and the public.

Both a lack of coordination and a lack of responsibility for implementation exists among stakeholders. In order to coordinate outreach efforts, territorial boundaries need to be overcome. These exist due to a lack of communication, as well as institutional turf battles. Stakeholders need to take responsibility for implementing nonpoint source pollution education, and coordinate their efforts.

Another barrier to nonpoint source pollution information/education is diversity throughout the state. School systems are structured differently in different areas, making it difficult to establish outreach programs on a statewide basis. Stakeholders are also diverse, and different interests and perceptions lead to disagreements among those that should be working together. The diversity of government agencies falls prey to political issues and conflicts in priorities. In order to have an effective information/education strategy, these diversities need to be acknowledged and dealt with.
A lack of resources exists for information/education support. Money and time are the most critical resources in the development of programs. Increasing the manpower dedicated to information/education efforts would go a long way toward establishing comprehensive programs. Consolidation of the resources throughout the state is also needed to avoid both redundancy and gaps in information or audiences.

Recommendations

1) Improve networking and communication among stakeholders involved in information/education efforts including, but not limited to, the following groups: civic, youth, business/industry, government, and private.
2) Establish a coordinating body to comprehensively address information/education issues in Indiana.
3) Establish a resource guide to assist in coordination of stakeholders.
4) Develop and distribute formal curriculum about nonpoint source pollution in Indiana.
5) Develop and distribute information sources on nonpoint source pollution in Indiana, such as newsletters, Internet sites, presenters and resource indexes.
6) Develop unique and innovative tools for teaching about nonpoint source pollution.
7) Develop television and/or radio programming highlighting nonpoint source pollution.
8) Provide hands on training to educators.
9) Provide inter-agency training to facilitate the transfer of information between agencies.
10) Hold conferences highlighting nonpoint source pollution information/education efforts.
11) Hold nonpoint source information/education events, such as water festivals, volunteer monitoring activities, contests, etc.
12) Hold media (news) events highlighting nonpoint source pollution.
13) Identify and list sources of government and/or private funding for information/education projects.
15) Work with private companies, foundations and non-profit groups to establish new funding sources and/or partnerships for information/education projects and coordination.
16) Develop and conduct grants writing workshops to assist stakeholders in obtaining funding for nonpoint source pollution efforts.
17) Utilize in-service training days to educate teachers about nonpoint source pollution.
18) Actively work towards securing increased nonpoint source pollution funding.

CHAPTER NINE: ATMOSPHERIC DEPOSITION

The atmosphere is an important component of the hydrologic cycle to be considered when assessing the effects of contaminants in the environment. The atmosphere is recognized as a major pathway by which pesticides, trace elements, and other organic and inorganic compounds are transported and deposited in areas far removed from their source (Majewski and Capel, 1995). The deposition of contaminants by wet and dry deposition may have a significant adverse effect on water quality in surface and near-surface waters and is becoming more widely acknowledged as an important contributor to the declining health of aquatic ecosystems. The bioaccumulation and/or biomagnification of pesticides and trace elements in biota have been observed around the world. Mercury contamination and the detection of DDT and PCBs in aquatic biota in the Great Lakes provide evidence of the long-range transport of some atmospheric contaminants.

Analysis

Natural and anthropogenic processes emit contaminants to the atmosphere that are later deposited to the Earth's surface. The atmospheric-depositional process can be classified into two categories: those involving precipitation, called wet deposition, and those not involving precipitation, called dry deposition (Bidleman, 1988). Removal of contaminants from the atmosphere involving fog, mist, and dew lies somewhere between the wet and dry processes but is more closely related to dry deposition.

Annex 15 (Airborne Toxic Substances) of the Great Lakes Water Quality Agreement between the United States and Canada mandates that "the parties," in cooperation with State and Provincial Governments, shall conduct research, surveillance and monitoring and implement pollution control measures for the purpose of reducing atmospheric deposition of toxic substances, particularly persistent toxic substances, to the Great Lakes Basin Ecosystem.

Trace elements are emitted into the atmosphere by natural events and from anthropogenic sources. Aluminum, arsenic, cadmium, chromium, copper, manganese, nickel, lead, selenium, and zinc are emitted to the atmosphere from smelting operations, steel manufacturing, electroplating or galvanizing, battery manufacturing, waste incineration, and fossil fuels combustion. Mercury is emitted to the atmosphere from background and anthropogenic sources. Forest fires and other high temperature natural events emit partially oxidized mercury as a particulate and as gas-phase forms of mercury. Background emission of mercury also includes mercury previously deposited from natural and anthropogenic sources. Anthropogenic sources of mercury include industrial emissions; metal-extraction processes; agricultural uses of mercury, paints, waste disposal (incineration and land disposal); heating of fossil fuels, ores, and other industrial minerals; and the combustion of fossil fuels for electricity generation (Porcella, 1997).

Pesticides have been recognized as potential air pollutants since 1946 (Daines, 1952). Before the 1960's, atmospheric pesticide contamination was generally thought of as a local problem caused by spray drift. Long-range movement of pesticides was thought to be minimal, if any, because of pesticides' low volatility and low solubility in water. The detection of DDT and other organochlorine compounds in fish and mammals in the Arctic (Cade and others, 1968; Addison and Smith, 1974) and Antarctic (George and Frear, 1966; Sladen and others, 1966; Peterle, 1969) changed this notion. In addition, mosquito abatement and other large-scale programs to eradicate such pests are examples of pesticide applications directly into the atmosphere with the intention of maximizing the coverage area using areal drift. In 1995, 11,800 tons of pesticides were applied to corn and soybean crops in Indiana (Indiana Agricultural Statistics Service, written communication, 1996).

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) collects wet-deposition samples at approximately 200 rural sites. Currently, two NADP/NTN sites are located in Indiana (Indiana Dunes National Lakeshore and Huntington Reservoir). The program was designed to provide regionally representative data for the assessment of spatial distributions and temporal trends in concentrations and depositions of major cations and anions in precipitation (National Atmospheric Deposition Program/National Trends Network, 1997).

The Integrated Atmospheric Deposition Network (IADN) is a joint effort of the United States and Canada to measure atmospheric deposition of toxic materials to the Great Lakes. The main focus of IADN is to determine regionally representative atmospheric deposition loadings of organic chemicals and trace elements to the Great Lakes. Eleven organochlorine chemicals, five trace elements, and four polynuclear aromatic hydrocarbons (PAHs) are being analyzed in wet and dry deposition at sites located around the Great Lakes.

Recommendations

1. Research activities need to be conducted to determine the pathways, fate, and effects of toxic substances in wet and dry deposition. Research activities should include:

- identification of the sources of airborne toxic and acidic pollutants;
- identification of the toxic substances that need to be monitored;
- determination of the number of monitoring and surveillance stations;
- the locations of surveillance stations;
- the equipment to be used at each station; and
- development of appropriate quality-control and quality-assurance procedures.

2. Conduct surveillance and monitoring to establish an integrated atmospheric deposition network for wet and dry deposition to identify toxic substances and, in particular, persistent toxic substances, and to track their movements. Utilize this network to:

- determine atmospheric loadings of toxic substances to surface and near-surface waters by quantifying the total and net atmospheric input of these same contaminants;
- define the temporal and spatial trends in the atmospheric deposition of toxic substances.

3. Develop models of the intermediate and long-range movement and transformation of toxic substances to determine the significance of atmospheric loadings to surface and near-surface waters relative to other pathways.

4. Cooperate in Great Lakes and national precipitation monitoring programs.

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CHAPTER TEN: RECOMMENDATIONS FOR MONITORING OF NPS-RELATED PROJECTS

OBJECTIVES

1. To develop a "minimum monitoring standard" for determining the effectiveness of nonpoint source projects.
1. To recommend a minimum set of data elements to allow for comparability of NPS monitoring studies.
2. To recommend a system of information management so monitoring data can be shared with all users.
3. To recommend an appropriate level of monitoring that can identify and help reduce NPS pollution in Indiana.

ASSESSMENT MADE

The Intergovernmental Task Force on Monitoring Water Quality (composed of a variety of State and Federal environmental agencies) has published a report (2/95) which summarizes their work and recommendations. we tried to incorporate as much as possible from their report into our own committee work. One important element of the report includes a recommendation that a particular "minimum" set of data elements be included in all monitoring reports to allow comparability between various studies. Another important element requires that enough information be included in the monitoring study to allow decision makers to assess data quality.

We also examined monitoring issues which would be most important in identifying and controlling NPS pollution in Indiana.

Recommendations

1. All studies reporting on monitoring results should state the purpose for monitoring:
   - To define existing conditions?
   - To measure trends?
   - To evaluate the effectiveness of programs?
   - To provide information to resource managers?
   - To characterize and prioritize problems?
   - To determine what is causing problems?
   - To respond to emergencies?
2. All monitoring reports should include the following data elements:
   - Sponsoring organization
   - Principal investigator
   - Location of data
   - Project description
   - Project duration
   - Project methods
   - Project products
   - Quality assurance procedures
   - Data quality objectives

Waterbody name
Waterbody type
Site name
Latitude and longitude of study site
Sample start date
Sample end date
Sample medium
Sample method
Variables measured
Measurement method
Detection limit values
QA/QC results

3. All study results should be reported in a form which can easily be shared with other users (a networked, distributed database rather than a centralized database). Production of both hardcopy and computer-readable reports should be encouraged. Distribution of results by telecommunications (internet) should be encouraged. There should be a way to advertise the existence of the study to all interested users.
4. Whenever possible, NPS monitoring projects should use some type of ambient water quality or biological assessment technique instead of or in addition to other types of less rigorous monitoring techniques sometimes employed (e.g. land management audits, model projections, photographs, landowner surveys, etc.).
5. Biological assessments should include an analysis of phytoplankton or periphyton whenever possible. These biological components of waterbodies respond most quickly to changes in sediments and nutrients and are an important indicator of NPS-related water quality impairment in Indiana.
6. Funding agencies should consider requiring a similar level of monitoring in all NPS studies. About 10-15 percent of the project budget has been allocated for monitoring in many successfully administered NPS projects. Monitoring should be encouraged both before and after project completion to determine the program's effectiveness.

PUBLIC FEEDBACK ON WATER RESOURCE CONDITIONS

The Monitoring & Prioritization Subcommittee realized that a quantitative method for evaluating the impact of nonpoint source pollution on the streams of Indiana was needed. A questionnaire to refine and update the original waterbodies prioritization list (from the 1989 NPS Plan) was developed, in addition to a scoring method for ranking watersheds. The questionnaire will serve to alert the Program to water resource problems that may not have been identified by routine monitoring. The organizations completing the form are required to state whether the information they used was qualitative or quantitative, qualifications of the individuals completing the form, and copies of data used to complete the form.

Due to the development of the Unified Watershed Assessment and some advances in data management since the original survey was developed, the Subcommittee will be asked to revise the questionnaire to current standards when the NPS Plan is approved. This survey will be made available to the public on the Internet, submittable by email, fax, or mail at any time during the year.

The watershed ranking method the subcommittee developed has since been superseded by the Unified Watershed Assessment, which built on the original work of the subcommittee but added many layers of data and a more complex scoring system for a more comprehensive ranking tool.